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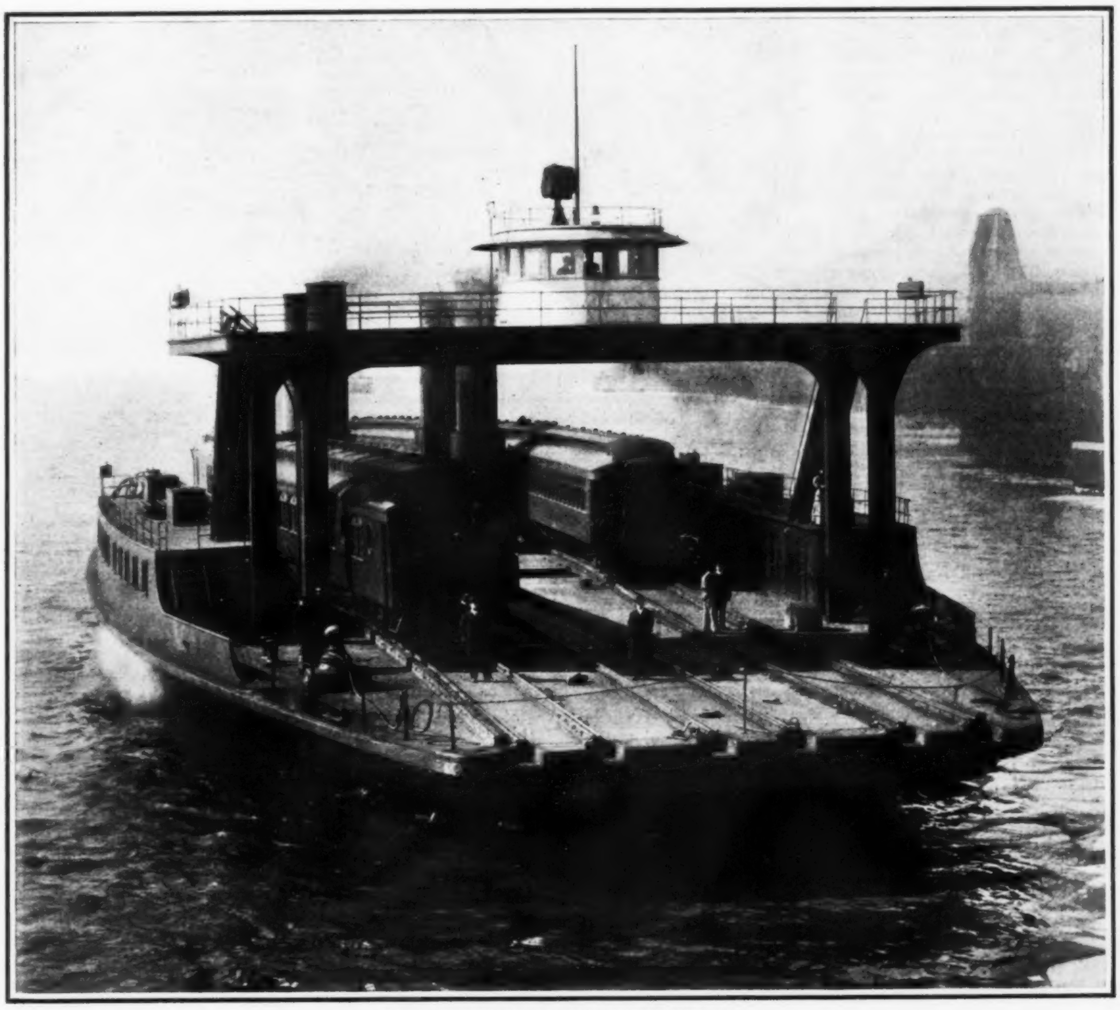
CAR-FERRY STEAMER "DETROIT," MICHIGAN CENTRAL RAILROAD.

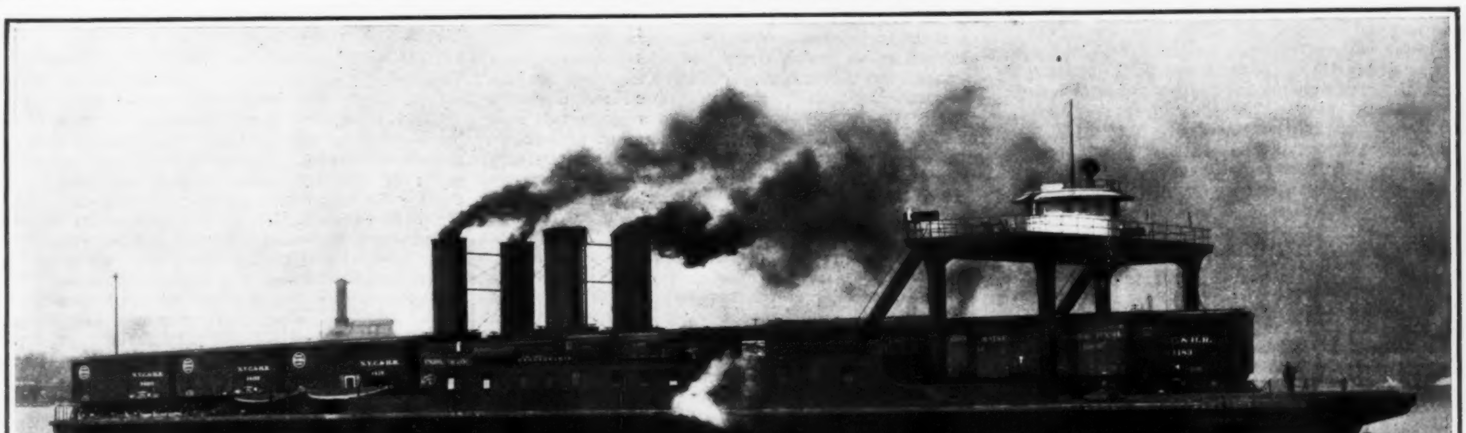
The car-ferry steamer "Detroit" shown in the accompanying illustrations was built for the Michigan Central Railway by the Great Lakes Engineering Works, of Detroit, Mich. The vessel is used in the Detroit River service between Detroit, Mich., and Windsor, Canada. Of the five steamers of similar kind owned and in use by the Michigan Central, the "Detroit" is the only one not propelled by side wheels. She is a four-screw vessel of exceptional size and power, and was designed to serve as an ice-breaker and to maintain communication through the heaviest ice. The vessel demonstrated her capability for this kind of work during the latter part of the past winter, contending successfully with very heavy ice and ice jams during the month of January. The "Detroit" is able to develop the high average speed for a vessel of this class of 18 miles an hour. The river at the point of crossing is half a mile wide and the time allowed for the trip is ten to twelve minutes, including landing.

The "Detroit" has a displacement of 3,850 tons, and the draft, normal, is 10 feet, and loaded, 14 feet. The length over all is 308 feet, beam of hull 64 feet, and beam over the guards 76 feet. The molded depth is 19 feet 6 inches. She has four smokestacks which rise directly from the deck below which the engines and boilers are placed. The vessel can carry 24 freight cars or 12 Pullman cars. There are three tracks for this purpose, the two outer ones running around the smokestacks. The cars are secured to the tracks by means of clamps and chains.

In summer the crew numbers 34 officers and men, while in winter this number is increased to 55. For the accommodation of these, as well as for the American and Canadian customs officials, two deck houses are provided, one on each side of the deck. These also contain special quarters for the superintendent and superintending engineer of the railway company's marine department. The deck houses are about 90 feet long and the top of each of these forms a promenade deck. At the bow is a high steel bridge which spans all three tracks and carries the pilot house, for while the "Detroit" has rudders and screws at both ends, she is not normally double-ended, and the



END VIEW OF THE "DETROIT."



THE CAR-FERRY STEAMER "DETROIT."

said arrangement of the screws and steering apparatus is merely for use in maneuvering. At each side of the river the boat is run with its bow against a pier or slip having three tracks corresponding to those on board.

The means of communication between the pilot house and the engine room are thorough. The levers in the pilot house for the four tell-tales in the engine room are provided with push buttons, each of which rings a bell in the latter. A lamp in front of the pilot is included in the bell circuit and indicates when this is closed and the bell is ringing. Besides this, there are four pairs of small red and green lamps before the eyes of the pilot, one pair for each engine. These show at a glance what engines are working and in which direction, the illuminating of a green lamp indicating that a particular engine is working ahead, while the corresponding red lamp is burning when the same engine is reversed. Two direct-connected dynamos supply current for the entire lighting system of the vessel as well as for a large searchlight.

The four engines are of the compound marine type with cylinders 24 x 33 and 48 x 33 inches. The crank shafts, of the built-up type with counterbalanced cranks, are 10¾ inches in diameter, the crank pins are 10 x 10 inches. All these and the journals are finished by grinding. The diameter of the thrust shafts is 11 inches, of the line shafts, 10½ inches, of the tube and tail shafts, 11¼ inches. This last is increased to 11¾ inches at the bearings. The tail shafts have taper fits for the screw. These are four-bladed, 10 feet 6 inches in diameter and 14 feet 6 inches pitch.

The trips of the "Detroit" are irregular, and consequently she may stay in the slip for several hours. In this case the hot-well supply is cut off by the stoppage of the air pumps—two twin vertical compound air pumps being used—and therefore a special feed system is used. There are duplicate compound boiler-feed pumps, whose suction pipes are connected to an open Cochrane heater. This is supplied with water from a large feed tank into the bottom of which two of the air pumps discharge. The feed-water supply is controlled entirely by the feed valves at the boiler, and the tank pump and feed pumps are fitted with pressure governors. The tank pump is shut down by its pressure governor when the feed pumps are stopped, as the water, rising in the heater, closes a valve in the delivery pipe of the tank pump by means of a float. The feed-water heater is supplied through a separator with the exhaust steam from the engines of the pumps, dynamos, fans and steering gear.

The four boilers are of the Scotch type and are built for 150 pounds pressure. Under ordinary circumstances, however, the working pressure is 100 pounds, but when the vessel is working in ice the greater output of the boilers is utilized. In case of necessity forced draft on the closed ash-pit system is available. The smokestacks are oblong and are 35 feet in height above the deck. For 14 feet of the 35 they are enveloped by casings which serve as ventilating trunks for the fire rooms. The coal bunkers, which have a capacity of 300 tons, are supplied through deck openings 40 feet long between the rails of the outer tracks, the coal being brought aboard in hopper bottom cars.

The "Detroit" differs from the usual type of ice-breaking steamer in that she is designed to cut and force a passage through the ice instead of sliding up upon it and crushing it by the sheer weight of the vessel. For this purpose the keel is straight from end to end instead of being curved upward. The steel hull is very heavily built. The frames are steel channels 10 x 3⅝ inches, spaced 24 inches apart. The engine frames are carried by four lines of box girders. The deck beams are 15-inch channels with a camber of 6 inches in 64 feet. They are spaced 4 feet apart, center to center, and are supported by three rows of columns, each of which is composed of a pair of steel channels. Diagonals run from the tops of the outer columns to the sides of the hull. The deck projects considerably beyond the hull, and this projecting part is supported by 9-inch channels and angle-iron struts to the hull. A continuous 12-inch channel runs around the edge of the deck. This channel carries an oak fender timber 6 x 12 inches, faced with a steel plate 1 x 9 inches. The 80-pound track rails are carried on I-section girders. These are built up of four angles, the vertical legs of the upper pair of angles being between those of the lower angles.

EPOCHS IN MARINE ENGINEERING.*

By GEORGE W. MELVILLE, Rear-Admiral, U.S.N., Retired.

To attempt to cover the history of marine engineering in a lecture which ought not to pass much longer than an hour, would result in little more than a mere chronology and could not possibly be interesting. It seems much better, therefore, to give some consideration to the various periods or epochs in the history considered with reference to the special inventions or changes which have characterized them. Many of these changes are clear examples of evolution and others are instances of the adaptation of land practice to marine use, but they all serve to show the constant progress which has taken place.

THE PADDLE WHEEL.

The first marine engineering in the modern sense was the adaptation of the steam engine as already in familiar use on shore to a modification of the centuries old method of mercantile propulsion, the oar. Some attempts were actually made to adapt the steam engine to a series of oars, which would have meant something like a mechanical trireme; but of course the trained mechanical sense soon saw that the collection of the oars in a revolving wheel was the correct solution. As oars had been used on both sides, so it was natural at first that the paddle wheels should be on both sides; a center wheel was also tried, but it is interesting to remark that practically about the same time that the sidewheels were used on the seaboard, the first marine engine was the shore engine modified to suit the circumstances, and thus on the seaboard the engine was designed and worked with what we now consider an exceedingly low pressure. On the western rivers where the change has been made in the location of the wheel, there was also the additional change of dispensing with the condenser and using very much higher pressures. It was doubtless due to this fact—that the first non-condensing engines really carried a very high pressure—that the term "high pressure," in the early days meant non-condensing. The reason for the difference is of course very clear; the western rivers are very shallow and it was necessary to make the machinery as light as possible; on the seaboard and the rivers of that section there was deep water and the vessels had displacement enough to permit of heavy machinery.

Ordinarily the history of this olden time could have only an antiquarian interest for us, but we are unusually fortunate in still having with us in the active practice of his profession an engineer who saw the first commercially successful steamboat, the "Clermont," so that through our "grand old man of engineering," Mr. Charles H. Haswell, we still have a living connection with that earlier time. One of my former assistants some years ago contributed a series of articles to one of the engineering magazines, and has given some data as to the performance of the "Fulton," the first American steam man-of-war, whose machinery was designed by Mr. Haswell, who was also her first chief engineer. An extract from the "Fulton's" steam log for January, 1838, shows that the maximum steam pressure was eleven pounds, the vacuum twenty-four inches, and the maximum revolutions per minute eighteen.

THE SCREW PROPELLER.

As time passed on and experience was gained, there was naturally an improvement in workmanship and design, and a moderate increase in steam pressure, but about 1836 the screw propeller was brought forward for driving large vessels. This was not the first application of the screw propeller, which had been used successfully on a small steamer or launch about 68 feet long as early as 1804 by Col. John Stevens, the grandfather of Col. Edwin A. Stevens, who is now so active in marine work, and the father of Robert L. Stevens, who was the most famous of the name for his work in connection with marine engineering. It is to be noted that this date is prior to that of the building of the "Fulton," but naturally, in the first steam war vessel, it was not considered desirable to do anything of an experimental nature, a condition which has obtained to some extent ever since and probably always will. It was about ten years later that the propeller began to come into general use and entirely displaced the paddle wheel for ocean-going steamers. The reason for this change is easy to see on a little consideration. On a long ocean voyage the change in displacement is due almost entirely to the consumption of fuel. In the case of the propeller this makes practically no difference in its immersion or in its efficiency, while in the case of the paddle wheel the immersion of the floats would be changed, with a diminution of efficiency. Further than this, the paddle box offered very great resistance to strong head-winds, and also brought severe stresses on the ship, due to rolling in heavy seas, the propeller not being affected by either of these last two causes. To-day for work in deep water, the screw, of course, is the only propeller; but for river work, particularly in shallow rivers, the paddle wheel is still used. Efforts have been made, and some of them exceedingly ingenious, to adapt the propeller to use in shallow water, and a certain amount of success has attended the efforts of such brilliant engineers as Yarrow and Thornycroft, not to mention our own Mr. Charles Ward, who has done some work in this connection. The fact remains, however, that damage by sand bars, snags, etc., may easily render screw machinery inoperative, while as expressed by an engineer who had designed many western river boats, "any wood butcher can repair a stern wheel."

Probably fully as much has been done to improve the design of propellers, as time has gone on, as any other part of marine machinery. In the early days the rules for propeller design were exceedingly crude, but with the slow engine speeds which then obtained the effects were not noticeable. As engine speeds increased, however, it was seen that these old rules were utterly inadmissible. There is no good excuse, however, for progress having been so long delayed, for the designs still remained too crude even after Isherwood's famous Mare Island experiments in 1868. Probably one of the great troubles with screw propeller design at the beginning was the mistake made in considering the action of the screw as analogous to that of a bolt working in a nut, from which it was inferred that the smaller the slip the greater the efficiency. As a matter of fact, a screw propeller is really a pump for driving a mass of water astern, the reaction from which drives the vessel ahead. When this had once been realized, it was seen that there must be a certain amount of slip and that under proper conditions there could be a relatively large slip and still high efficiency.

Multiple screws were used as early as our civil war on some vessels known as "tin-clads" on the Mississippi, their adoption being necessitated by the shallow draft. Twin screws were first used in war vessels where the necessity for keeping the machinery below the deck would not allow of all the power being conveniently used on a single shaft, but the great advantage they possess of security against total disablement and for maneuvering soon made them the rule for all naval vessels large enough to admit of them. They were much longer in coming in the merchant service where the limitations on naval machinery do not obtain; but since the era of the very large transatlantic steamers beginning with the "Paris" and "New York," and the "Teutonic" and "Majestic," all very large vessels have been built with twin screws.

In the navies of France and Germany, the triple screws have been used to a considerable extent and I used them myself in our fast cruisers "Columbia" and "Minneapolis." My own belief is that they have decided merit for vessels using about 10,000 horsepower. This view, however, was not shared by my Board colleagues in the Navy Department, so that their marked success in the two vessels named was not allowed to be repeated in later designs.

With the advent of the steam turbine as a prime mover in ships multiple screws have again come to the front, this time on account of the extremely high speed of rotation of the shafts. The "Turbinia," the first vessel of this kind, had three shafts with three propellers on each; and the destroyers "Viper" and "Cobra" had four shafts with two propellers on each. The merchant vessels, beginning with the "King Edward," have been fitted with three shafts.

Before leaving the propeller, I may mention, in connection with the improvements in its design, the care that is now taken to avoid needless friction by making the hub spherical with a conical tail piece, and by putting covering plates over the bolts, securing the plates to the hub so as to continue the outline of the sphere or conoid.

THE SURFACE CONDENSER.

Up to about 1860 the jet condenser was the one usually employed on board ship, which meant, of course, that the boilers were constantly fed with salt water; and this, in turn, meant the deposition of great quantities of sulphate of lime scale on the heating surface. With the low pressures then prevalent this did not greatly affect the economy of the boilers, except that, as "blowing off" to keep the density of the water down was a continuous practice, there was a certain loss of heat, and of course there was the necessity for frequent scaling of the heating surfaces. However, they were effectually protected against corrosion. About 1860 the use of surface condensation became general, and as this greatly reduced the amount of scale formed, it was practicable and safe to increase steam pressures, which accordingly resulted with a consequent reduction in the weight of machinery per unit of power.

An accompaniment of the introduction on shipboard of surface condensation, which was at first supposed to be a result of it but which as a matter of fact was not, was a tremendous increase in the corrosion of the boilers and shortening of their life. This was especially noticeable in the tubes which, as the thinnest part of the boilers, give out first. All sorts of theories were advanced to account for it, some of which we can now see to have been utterly ridiculous. Probably one of the most fanciful was that which regarded the boiler and condenser as forming a gigantic galvanic battery, the copper condenser tubes forming one pole, and the boiler the other. The real facts were developed as a result of the investigation by the Admiralty committee on boilers in the 70's, which showed that boiler corrosion was simply rusting and had been due to gross but unintentional neglect. It had been a very common practice, particularly in naval boilers, when they were not in use, to blow out the water and take off the manhole plates "to let them air." It was this "airing" which caused the corrosion. Now when boilers are laid up, they are filled with water which is made slightly alkaline, and this effectually prevents corrosion.

THE CYLINDRICAL BOILER.

The early boilers in sea-going vessels were of what has been called the "box" type; that is, the boiler was a cubical box with a thin shell, the real strength being given by braces running in three directions. When surface condensation had made higher pressures possible, it was soon found that the multiplicity of braces, as pressures were increased, made an impossible condition of affairs, and this led to the design of the cylindrical boiler whose shell was self-bracing and left the only braces, those needed for the heads and flat surfaces. This boiler so thoroughly met the conditions arising that it has remained the favorite even up to the present day. At one time an effort was made to save room by making the boiler elliptical, but this was soon found to be unsatisfactory and impracticable, and was abandoned after only a few examples.

The earliest marine cylindrical boilers were single-ended with two furnaces, but with the advent of reliable mild steel the diameters were increased and the boiler was made double ended, with upper ends rounded to save bracing, so that the largest cylindrical boilers to-day have as many as eight furnaces, four in each end in pairs; that is, the two furnaces at each end on the same side of a vertical diameter have a common combustion chamber. The saving in weight due to the double ended boiler is evident at once and also the reduction in the feeding apparatus required.

Notwithstanding the advent of the water tube boiler, which will be mentioned further on, and its practical preëmption of naval practice, the cylindrical boiler still

* Read before the American Society of Mechanical Engineers.

remains the favorite for the merchant service, and has been used for pressures as high as 220 pounds, even in the largest sizes on such vessels as the "Kaiser Wilhelm." The highest recorded pressure is 255 pounds on the "Inchdune."

THE COMPOUND ENGINE.

From a very early period steam has been used expansively in marine engines, and indeed sometimes to a ridiculous extent. Some engineers as late as the civil war hardly seemed to realize that there was any limit to expansion, although Isherwood's famous experiments on the "Michigan" in 1861 had demonstrated conclusively that, with low pressures, only a very moderate expansion is permissible, beyond which any further expansion is attended by an economic loss. As pressures increased it was natural and correct that a higher range of expansion should be used, and this made practicable the compound engine, where the expansion occurs in two stages, the high pressure steam from the boiler being limited to a small cylinder from which, in turn, the steam of lower pressure is exhausted to a larger cylinder. The compound engine was invented almost as early as Watt's separate condenser, Hornblower's patent dating back to 1771, and Wolff's patent for a two-cylinder engine dating back to 1804. With the low pressures prevalent at that time the compound engine was actually at a disadvantage compared with the simple one. When pressures had gotten up to about 60 pounds, however, the compound engine began to assert itself, the pioneer in that respect being John Elder, of the firm of Randolph & Elder, which is now known as the Fairfield Engine Works. It is interesting to note that the Allan Line of steamers, which is now the pioneer in introducing the steam turbine for an ocean-going steamer, made the last scientific stand against the compound engine, going so far as to take duplicate vessels, and engine one with compound and the other with simple engines of the same power. The actual experience with these two vessels where the simple engine with the high ratio of expansion was constantly in trouble from breaking down, was a convincing proof that high ratios of expansion in a single cylinder were impracticable.

With the improved workmanship which had come by this time and with the improvement in materials, to which we shall refer in a moment, which came later, the compound engine advanced to a high state of perfection, and for large powers the three cylinder type, with one high pressure and two low pressure cylinders, became a favorite for all large vessels. These engines were probably as fine specimens of marine engine designing as have ever been seen, and included some exceedingly ingenious valve gears designed to secure variable expansion and an equalization of work among the various cylinders. As we shall see later, the further advance relegated these beautiful mechanisms to the engineering museum.

THE ADVENT OF MILD STEEL.

It is probably difficult for the young men in our technical schools of to-day who are familiar almost entirely with mild steel and very little with wrought iron, to realize what a change came in engineering when the production of mild steel became a commercially reliable matter. When we look back at the way in which some of the vital elements of a big marine engine were made, we are almost inclined to wonder that the material was reliable at all. The difference between a large wrought iron shaft such as old Hughey Dougherty used to make at the Morgan Iron Works, and one of the mild steel shafts made at Bethlehem, is as great as could be imagined. Nearly the same is true of boiler plates. The young engineer of to-day would hardly know what was meant by a lamination or a "cold shut." The very method of manufacture made it necessary to use a large factor of safety in designing, with the result that the working stresses permissible were very low and the weight of machinery inordinately high. With the advent of mild steel and the introduction of careful and systematic testing, the designer had a material on which he could place absolute reliance so that the factor of safety could be greatly reduced. As a matter of fact the factor of safety has been reduced from 8 or 10 to 5, and sometimes as low as 4.5.

In looking back over my own experience, I do not see how we could possibly have built engines of the size and power now common with wrought iron for piston and connecting rods and shafting, and it is, of course, absolutely certain that we could not have built cylindrical boilers of to-day. The change began in the later 70's and had become almost complete by the middle of the 80's.

We must not fail to notice in the change to steel the use of steel castings, which have displaced cast iron in many places with attendant great reduction in weight. The first use of steel castings was attended with considerable annoyance because it was unfortunately assumed, perhaps naturally, that, barring the much greater shrinkage, it could be treated very much the same as cast iron, and it was consequently asserted with confidence that anything which had been made in cast iron could be made in cast steel. That is doubtless true to-day, but it certainly was not true ten or fifteen years ago, as I know to my personal sorrow, because designs which would have been considered simple in cast iron had to be entirely changed to meet the conditions then existing for steel castings.

It may be well to mention in this connection that about the same time that steel came into use displacing wrought iron, white metal for bearings and the stronger bronzes also came into use, thus giving the designer much better materials to work with and again reducing weights.

We may also state here the gradual displacement of copper for steam piping by steel pipes, owing to the fact that for the high pressures common at present copper pipes would have to be very thick, making it difficult to secure a sound joint, and also to the serious diminution of the strength of copper by the high temperature.

FORCED DRAFT.

Forced draft dates back of course to Stevens' "Rocket," and its first use for marine purposes was by Mr. Robert L. Stevens on the Hudson River steamers in our own country prior to the civil war. During that war Mr. Isherwood built a number of gunboats which used forced draft, but it had fallen into disuse until about 1882 for naval vessels, when it was introduced into the English navy, and still later was applied in the merchant service.

In naval machinery forced draft has been of the greatest possible importance, because it has reduced boiler weights probably almost one-half. In the navy the natural limitations as to space and weight prevent the use of forced draft with very much economy of fuel. It is obvious that if the rate of combustion is increased from 15 pounds of coal per square foot of grate to 40 pounds, there ought to be an attendant increase of heating surface. In the merchant service, or at least in certain classes of vessels in that service, it is possible to do this, and in one of my annual reports I made a comparison between the boilers of a merchant vessel called the "Iona" and those of the "Baltimore." In the "Iona" there were 75 feet of heating surface for 1 grate, while in the "Baltimore" the ratio was about 30 to 1; but had the "Baltimore's" boilers been designed with any such ratio, their weight would have been almost double the weight of all the machinery of that vessel as actually built.

Mr. James Howden has made a specialty of forced draft under economical conditions, heating the air before admission to the ash-pit; and his system is now in use on most of the large steamers, the aggregate horse-power running up, I believe, to over a million.

HIGH ENGINE SPEED.

About the same time as the reintroduction of forced draft in naval vessels, the improved materials and workmanship made it possible to get higher rotational speeds, and, as remarked earlier, the true conditions of propeller design being understood, there was a marked increase in the speed of rotation of the engines. Naval engines, from the necessary limitation of keeping the vital parts of the machinery protected as far as possible, have always run faster than the engines of the merchant service, although this did not always mean that their piston speed was greater. The mistake is sometimes made of attributing lighter machinery to higher piston speeds, but unless this is accomplished by increasing the number of revolutions it will not produce that effect. In the early days, 60 or 70 revolutions per minute for what was then considered a large engine of 4,000 or 5,000 horse-power, was about the limit, but in engines of as much as 8,000 horse-power for a single set one finds the revolutions to-day as high as 130. Of course it is not practicable to show to just what extent any one line of progress has reduced weights by comparing the machinery at periods wide apart, because the increase of steam pressure, increased rotational speeds, improved materials and better designing have all gone along together—but it is interesting to note that in the "Warrior" of 1861, with 22 pounds boiler pressure and 54 revolutions, the horsepower per ton of machinery was 6, while in the "Minneapolis" of 1891, with 165 pounds pressure and 133 revolutions, the horse-power per ton is 10.9. From a simple mechanical standpoint, contributing agencies to the high speeds are the much more perfect journals of the steel shafts, and the superior white metals used for bearings, and the rigidity of the steel hull of the ship, as compared with the older conditions. The best makers now grind their bearings true to a mandrel which represents perfect alignment. In the old days all main shaft bearings were hollow for water circulation, which was generally needed, and there was usually provision for a spray of water on the crank pins. In the modern engines which have been well built and are carefully adjusted, there is no necessity for water even at very high speeds under full power.

THE MULTIPLE EXPANSION ENGINE.

The change from the simple to the compound engine involved a certain amount of difficulty and opposition, but the lesson was then learned pretty thoroughly that the amount of expansion in a single cylinder was moderate. Consequently, as steam pressure rose, the leaders of the profession became convinced that to secure adequate economy a further stage of expansion was necessary, and this brought about the triple expansion engine, the credit for which is deservedly given to Dr. A. C. Kirk, of the firm of R. Napier & Sons, of Glasgow, who first successfully used the triple expansion engine on the steamer "Aberdeen." The adoption of the triple expansion engine was almost immediate, and, after the success of the "Aberdeen" was demonstrated, all new engines of any size were built on that principle. It seemed a logical extension of this idea that with still further increase of pressure there should be the quadruple expansion engine, and a number of these have been built; but the advantage as compared with the triple expansion engine up to the point beyond which pressures have thus far not gone, does not seem to be clearly demonstrated, and a great many designers are adhering to the triple expansion engine with four cylinders, one high, one intermediate, and two low pressures.

WATER TUBE BOILERS.

Like so many other details not only in marine engineering but in other lines of work, features which are introduced in a practical way in recent times are found to have a comparatively ancient origin. This is true of the water tube boiler, which in its recent use dates from about 1880. The excavations at Pompeii have shown small boilers almost identical in construction with some of the best of our water tube boilers, although they were doubtless only used for a circulation of hot water.

The object of the water-tube boiler is to reduce weights, give greater safety against explosion, greater rapidity of raising steam, and an increase of economy in the generation of steam. The various makes of water tube boilers are too numerous to mention, but they divide themselves into two broad, general classes; those with straight tubes of large diameter, say four inches; and those with curved tubes of small diameter, from an inch to an inch and a half. Probably no single boiler possesses all the merits which a perfect water tube boiler should have, and in nearly every case the attempt to secure certain advantages brings attendant disadvantages, and *vice versa*. The large straight-tube boilers are not so light as the ones with small tubes; and it is more difficult to secure adequate economy, which is dependent largely upon skillful baffling. They do not permit of such rapid raising of steam from cold water as the smaller tube boilers. Because, like the Scotch boiler, they carry a large reserve supply of water in the boiler after the manner of the Babcock & Wilcox boiler. On the other hand, they permit the replacement of a defective tube and of the cleaning of a tube much more readily than the tubes which are bent. Likewise it is only necessary to carry one size of spare tubes, while the bent tube boilers require several sizes and shapes.

As far as safety against explosion is concerned, there can be no doubt that there is less danger of an actual disaster affecting the whole ship—although the worst accident which we ever had with a boiler in my naval experience was in connection with a water tube boiler on a torpedo boat, where all the crew of a fire room were scalded to death. Nevertheless, the boiler itself did not explode and was quite easily repaired. On the other hand, a few years before this a locomotive boiler on a torpedo boat in Germany exploded through the collapse of the crown sheet due to low water, and not only killed all the people in the fire room, but tore up the decks and utterly ruined the boiler itself. In this connection it is a cause of sincere congratulation that since the explosion of the "Thunderer's" boilers in the English navy many years ago, there is, I believe, no record of the explosion of a large, well-built marine boiler. For naval purposes, where weight is such a great consideration, the water tube boiler commended itself at once, and it has now become the established practice in all navies to use only water tube boilers in new ships. Our English friends had some trouble with the Belleville boiler, but this seems to have been due to some extent to lack of familiarity with it, and other legitimate reasons. In the merchant service, where weight is not so precious, the water tube boiler has not thus far so thoroughly commended itself to designers; and, as remarked earlier, all of the latest large vessels are still using cylindrical boilers. Some of the reasons for the hesitation to adopt water tube boilers are that, of necessity, an installation of large power means a very large number of boilers, because the water tube boiler does not admit of single units of great power comparable with the large double-ended cylindrical boilers. This means an immensely greater complication in the way of piping, valves, fittings, feed pumps, etc. Moreover, owing to the small amount of contained water, which is very desirable in so far as weight is concerned, the water tube boiler is very sensitive as regards steam pressure and water level, requiring very much more care and attention than the cylindrical with its immense amount of contained water. It seems to me not impracticable that the able men who are engaged in the study of this question will finally succeed in developing a type of water tube boiler which will commend itself for use in the merchant service as well as in the navy. Some of the boilers fitted in the United States naval ships had but six minutes of water endurance after the pumps stopped working, while one of those, the Babcock & Wilcox, adapted to our naval use has as much as twenty-five minutes endurance, which is a close approximation to the Scotch boiler.

AUXILIARIES.

In the early steamers, almost the only independent steam auxiliary was a single pump which could be used for feeding the boilers while under banked fires or with the engine stopped, and for pumping the bilge. The other pumps were attached to the main engine. Such things as steam capstans, and winches, steam steering gear, distilling apparatus, evaporators, forced draft blowers, and electric light engines, were not dreamed of. As time went on and the size of vessels increased, steam capstans and winches and steam steering engines came in. Then it began to be found desirable, particularly for naval engines, to remove all the pumps from the main engine, leaving it nothing to do but turn the propeller, and this brought about independent air and circulating pumps and feed pumps. Further progress introduced the distiller and evaporator, the forced-draft blowers, and the electric light engine.

Most of these auxiliaries, from the nature of the

case, are driven by simple engines, the pumps usually being for very slow piston speed and without expansion. The result is that the economy of these auxiliaries is naturally very low, and for some years past it has been the aim of designers to do something to either make the auxiliaries themselves more economical or at least utilize the heat in the exhaust steam. In some cases it has been arranged to have the auxiliaries in the engine room take their steam from the first receiver and exhaust into the second, thus, in effect, making all their cylinders part of the intermediate cylinder, as far as the steam cycle is concerned, with its attendant economy. I remember one of my former associates telling of how he had actually tried this on his ship with a saving of some six tons of coal a day, for machinery which was then working at about 8,000 horse-power. In the case of the feed pumps, arrangements have been made to turn the exhaust steam into the suction pipe, thereby having this heat carried back into the boiler, but this has not been done to any very great extent. Another plan has been to turn the exhaust from all the auxiliaries into a feed water heater through which the main feed to the boilers would go, and this has been attended by very good results.

The question has been raised repeatedly by electrical engineers that it would be a good plan to drive the auxiliaries by electric motors, on account of their very high efficiency even at fractional loads. For the engine room auxiliaries and the boiler feed pumps it seems to me that this is unreasonable, for it means increased complication and certainly an increase in weight; and it has never been shown to my satisfaction that there would be any material increase in economy, owing to the fact that the dynamos as usually supplied on board ship are not large enough to have very economical engines, and from the fact that there are so many machines each with an efficiency less than unity in the circuit between the boiler and the final pump.

There are some auxiliaries on board ship, however, where it would seem motors could be used to advantage, notably for driving the forced-draft blowers. From the necessities of the case these are usually stowed in hot and rather inaccessible places, and it is difficult to keep the engines in good adjustment. It hardly seems to me, however, that direct current motors are well adapted to this service, as they would have to be of the inclosed or dust-proof type, which reduces their heat carrying capacity, and as they have to go in places where the heat is already very great. If alternating current machinery were installed, it seems to me that the induction motor with its extreme simplicity and ability to withstand very hard usage would be especially adapted to this work.

It is doubtless known to all of you that in the modern ships the turret turning is done by electric motors. While this is an engineering matter, on board ship it comes within the purview of the ordnance officer, and therefore I have not dwelt upon it. The anchor capstan and steering engine should be electrically driven, but because of peculiar conditions existing in the navy this has not been done.

THE STEAM TURBINE.

The latest note of progress in marine engineering seems to be the advent of the steam turbine, which for some purposes has passed the experimental stage, and has given great satisfaction. As already mentioned, a number of small vessels of the torpedo boat class have been built with steam turbines, and this has been followed up by their use in a number of excursion steamers and cross-channel steamers between England and France, and England and Ireland. The Allan Line of steamers have also decided to equip a large new steamer with turbines, and, as we all know from the technical press, the Cunard Company have had a very able committee considering the question of their adoption for the two new flyers which that company is to build—as a result of which they have decided to use turbines in them.

The turbine has had an extended use in the last four or five years on shore for driving electric generators, and this has been so satisfactory that the pioneer work of the Westinghouse Company in this country has been followed by the General Electric Company, the Allis-Chalmers Company, and a number of other engine builders, who seem to have reached the conclusion that for large powers at least the turbine is quite sure to supersede the reciprocating engine.

For constant speed at its rated load the turbine is very economical, comparing in this respect with the most economical reciprocating engines, and its economy does not fall off so rapidly with the decrease of load at constant speed as is the case with the reciprocating engine.

For marine purposes two questions have bothered those who were seeking information, one, the question of reversal, and the other, that of economy, where not only the power but the speed is reduced, as is, of course, necessary in the propulsion of vessels. With respect to the former, different methods have been suggested and tried in different cases. In some instances Mr. Parsons has used separate reciprocating engines which are normally idle. In others, and this appears to be in his latest practice, there are reversing turbines inside the exhaust passage of the ahead turbines, so that while the ship is going ahead these turbines revolve idly, after the manner of a fly-wheel, in an excellent vacuum. When the ship is to be reversed, steam is admitted direct to these turbines and secures the reversal.

With respect to economy, there is, of course, a marked falling off from that at full power, but not more so than in the case of reciprocating engines. It seems hopeless to expect that any machine will work with the same economy at one-tenth power that it does at full power, and it would be unreasonable to expect the turbine to do this when the reciprocating engine does not.

The advantages of the turbine are, the entire absence of reciprocating parts, of bearings to be adjusted and the extreme simplicity of operation, together with the great reduction in weight due to the very high speed. Added to this is the entire freedom from danger due to priming of the boilers, the only result being a slowing down of the turbine and reduction of economy. There is also freedom from lubricating oil getting into the boilers.

Propeller design with the turbine is more difficult than with the reciprocating engine, because the conditions are entirely different from those which have hitherto obtained, and there is so little experience with propellers running at speeds of over 1,000 revolutions a minute in the case of small ships, or at 500 to 750 in the case of large ones. The Cunarders' propellers, it is understood, are to be limited to 180 revolutions per minute. For it must be remarked that in spite of the fact that we now have very clear and logical rules for the design of propellers under existing circumstances logically worked out, nevertheless these rules and formulæ came after the experience rather than before. This matter, however, can undoubtedly be cared for, and when more experience has been gained the design of propellers will be as easy for existing conditions.

For naval vessels from a military standpoint the turbine has a great deal to commend it, inasmuch as the machinery will stow very well in the ship and be out of harm's way, the propellers are so small and so well immersed that there is no chance for racing even in the heaviest seas, and all questions of vibration are eliminated. As already mentioned, the saving in weight is also a matter of decided value, if it can be done.

CONCLUSION.

We have now considered very hastily the important epochs in the history of marine engineering, and it will be seen that they indicate steady progress along certain lines. There has been a steady increase of steam pressure, increase of rotational speed, and diminution of weight, accompanied by increased economy in the making and using of steam. If time had permitted it would have been very interesting to compare such a vessel as the "Great Eastern," which for so long a time was the criterion of immense size, with the "Celtic" and "Cedric," which are even larger than she was. The "Great Eastern" was simply about thirty years ahead of her time. She was a remarkable production and a great credit to her designers in every way, but she was a commercial failure, because marine engine manufacture had not yet reached the point where such a huge vessel could be operated profitably. She carried more than twice as much coal as one of these present day vessels, which easily makes the same speed with machinery weighing probably not more than one-third of what hers did.

The economy of the marine engine, or of the turbine if it displaces the engine, has reached a point which does not leave much room for improvement in materials and workmanship. Yet it will be unreasonable to believe that we have reached finality, for it is likely that there have been numerous periods in the past when the designers of those days could not see what the next step in advance would be, and so far as their knowledge went their design was nearly perfect. Of course there was certainly plenty of margin for increased economy with them from which we are barred, but I have no doubt that if I could live to be as old as Mr. Haswell I should see some decided improvements in the course of the next thirty years.

THE MANUFACTURE OF BRONZE COLORS.

"Economy is wealth," and our German cousins are renowned for their economies. It would seem as if they absolutely suffered pain when they see things going to waste. A proverb applied to the French originally, would prevail with equal force if attached to the thrifty Germans: "One million Frenchmen could live upon what one million Americans throw away." Our unequaled resources make us prodigal, their limited means of subsistence force them to be provident.

Thus we see the first effort to obtain value out of the waste material in the metal-beating establishments has resulted in the erection of a significantly independent industry, which has assumed a high degree of commercial importance, particularly in Germany. For many years, indeed, the bronze color factories situated at Nuremberg and at Furth dominated the markets of the world for these products. Only a comparatively short space of time has elapsed since there have been established in other lands factories capable of supplying, at least in part, their home demand, and thus working themselves up to a certain degree of independence.

From year to year the consumption of these colors increases; so popular have they become, in fact, that all trades and industries are now consumers; moreover, it may be safely maintained that there exists no branch of industry in which bronze colors are not used in one way or another.

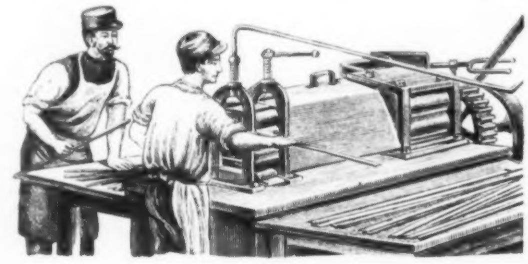


Fig. 1.—THE ROLLER WORK.

Fig. 2.—INGOT TRIP HAMMER.

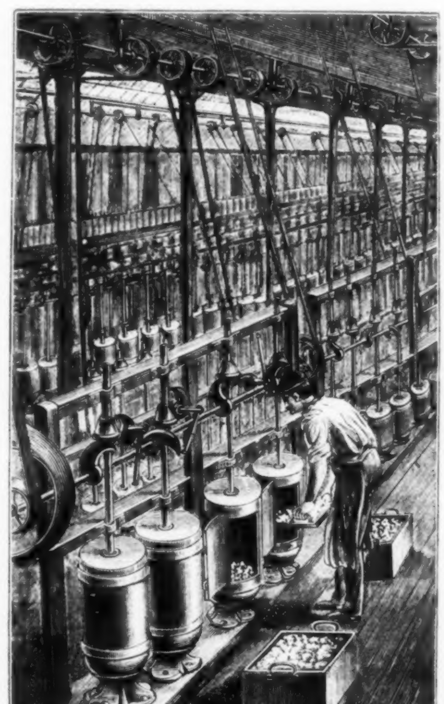


Fig. 3.—STAMP MILLS.

Bronze powders are graded as well according to the color of the alloy as to their fineness; and of course the cost of manufacture and the selling prices vary in consequence, the first on account of the greater quantity of labor required to reach the finer state of pulverization. The finer the metal powder is divided, the greater is the yield of material. It is more expansive, that is, a correspondingly larger surface can be covered with it, as well as a thinner film applied. The color of the product depends first upon the alloy, and also upon the heating or tempering, and just here let us say that there are a great number of varieties of these tempered powders sold, to which the artificially colored metal powders, the so-called patent bronzes, belong, considerable quantities of which are also found in the trade.

The fineness again depends upon the time and care expended upon the grinding and assorting, whereas the gloss of the bronzes is produced by the so-called polishing process.

Quite a peculiar kind of bronze colors is that known as gold leaf bronze, which is produced from leaf metal. It appears, not in the shape of a fine powder, but rather in thin fragments of a leaf, which possesses the gloss of leaf gold. When applied, they take up their positions side by side or shoved one over the other, and by virtue of their peculiar shape and placing, afford an especially intensive metallic gloss. The chief sorts of these bronzing powders are gold in the most varied shades, aluminium, copper, mainly as natural copper, silver alloys, and after them the different-colored bronzes. By heating and annealing, from forty to fifty various color tones may be produced, such as different shades of yellow, then brown, fire red, carmine, crimson, pale violet pink, green, and blue (ex-

cent light blue). Artificial coloring of the bronze powders consists in treating them with solutions of any or all of the aniline dyes, in mixing machines adapted for the purpose, until the desired tone is acquired, and yet these beautiful and very effective bronzes, glittering in their delicate blue, red, and violet tints, do not possess permanent qualities, but, when exposed to the light for a time, lose much of their attractive beauty. They serve mostly for the coating of massive articles in which the prime requisite is cheapness, after which durability straggles along, quite a secondary consideration. Bronze powders made from the alloys of zinc and copper are known as gold bronzes, and when made of pure copper, as copper bronzes; where the powders are made from tin, they are sold under the name of silver bronze. These latter are mostly made of beaten metal, and because of the great expense attending this method of manufacture, are sold at the top prices. Powders of real gold and silver are only exceptionally made. To these bronzes belongs also the iron black used to blacken the surface of plaster of Paris figures, even though, in the proper significance of the word, it is not a bronze at all. Iron black is a finely-divided metallic antimony, which is precipitated out of a solution of a salt of antimony by means of zinc strips suspended in it. Among the bronze-like substances that may be looked upon as substitutes for the bronze powders named above are: Yellow saffron bronze, consisting of a tungstate of tungsten; violet magenta bronze, or tungstate of tungsten and potassium; mosaic gold or tin sulphide; violet chromium chloride; crystallized lead iodide; murexide or purpurate of ammonia; hydroquinone, etc. When in competition with the real bronze powders, it is doubtful whether these substitutes for bronze, esepecially the expensive tungsten compounds, can maintain any advantage.

In addition to the metallic bronze colors, the so-called vegetable bronzes find extended application, for the purpose of tinting and otherwise beautifying a variety of manufactured articles. They are, however, greatly inferior to the metallic preparations, because theirs is a totally different character; they possess nevertheless a metallic gloss, as do also the various coal-tar dyestuffs when in a highly concentrated condition. The vegetable bronzes are lakes derived mostly from decoctions of logwood and Brazil-wood; they are prepared with a binder of some sort, and serve very nicely for printing upon wall-paper and leather articles of the finest grades, particularly in greenish gold and iridescent colors, and when thus used produce brilliant and often very beautiful effects. Brocade colors are less finely divided leafy products, a sort of middle product, which finds application in the wall-paper industry, as well as in the manufacture of variegated papers and in lithography for the ornamentation of fancy goods, etc. More or less finely ground mica, colored or in its natural shade, is also dignified with the name of bronze color, and it is almost as widespread. Beautiful as are the effects of these bronze colors directly after they are applied, if left uncovered and exposed to the air, or subjected to the prolonged effects of sulphureted hydrogen gas, they are not lasting. Within inclosed places, even without a coat of varnish, they maintain their pristine brilliancy pretty well, yet in the course of time they tarnish, that is, become green or black and lose their glossy appearance, which in fact they also give up when they are provided with a thin protective coat of varnish. When treated with acid, too, those bronze colors which contain copper become green, and will discolor even the resinous solutions that have been used to protect them; even the influence of the atmosphere turns them green and dark, as well as deprives them of their gloss. Notwithstanding all these disadvantages, the cheapness of the material makes it possible to restore by a new application their former brilliancy easily and quickly.

Passing now to the manufacture of the bronze powders, let us say again that for this purpose, a prime quality of base leaf metal, well hammered with mechanically-operated trip hammers, is used; and the waste material from the metal-beating establishments forms but an inconsiderable portion of the mass, when compared with the amount of metal consumed, this being used only as an unimportant adjunct.

Although the raw or unmanufactured material is furnished to most of the factories, so that the bronze-color makers, only in extremely rare cases, produce it for themselves, we deem it, nevertheless, advisable to describe the manner of producing the same.

The principal raw materials used in the manufacture of these bronze powders are copper and zinc. Of the first we have an extended choice with manifold qualities at command. Of these the Mansfeld copper deposits in Germany are the best, because of the uncommon ductility of the metal. After these comes the American copper from the Hecla mines, to be followed by lesser quantities of Spanish and Chile varieties of copper, which are partly refined in England. Only the very best grades of zinc are employed, and these are preferably the refined metal from Silicia. The metals are melted together in Passau graphite crucibles containing about 200 kilogrammes each. These crucibles are arranged and built into a solid furnace called the ingot smelter, and in them the metals in the required proportions are placed. An intense fire of coke is now applied, and in from four to four and one-half hours the operation is completed and the alloys drawn off into molds, which form half-round bars about 30 centimeters long, 1½ centimeter wide, and of about the same thickness. The iron molds are inclined to crack when the molten liquid is poured into them, and to obviate this they are thickly smeared with tallow; the molds are filled by hand from small casting pots. When cool enough to handle, the bars are bound together in bundles, and transported to the hammer rooms, where they are worked into shape, the unevenly formed castings being made uniform and symmetrical. When this is satisfactorily accomplished, they are carried to the roller room, where they are passed between successive sets of steel rollers, twenty in all, and thus drawn out into ribbons, many meters long. The drawing or rolling process generates considerable heat in the metal. As a consequence, they must be well greased and cooled under a constant flow of water. Nor is this all. At different periods in the rolling out, the ribbons must be annealed, because under the working the metal of the rollers becomes very hard and brittle.

FIG. 4.—RUBBING MACHINE OR CHASER.

For this purpose special annealing furnaces are constructed, in which wood only may be used as fuel, because in the burning of coal sulphurous combinations are evolved, which add much to the brittleness of the metal. These ingots are thus rolled out into bands or ribbons measuring from 10 to 25 meters in length and of a uniform width of 3 centimeters. They are now cut into lengths of 60 centimeters, and from 100 to 200 of them bound together and beaten out between sheets of zinc under the ingot hammers driven by water or steam power. A very singular circumstance attends this beating; they expand practically only in the width, their longitudinal increase being hardly appreciable.

These bundles after being thus stretched are again annealed to restore their ductility. Now two of these bundles are bound together, containing from 200 to 240 sheets of ribbon, and subjected a second time to the working of the trip hammers. Under this pounding they are kept until they reach a width of about 8 centimeters. Again they are softened in the annealing

FIG. 5.—STOVE WITH HOOD, FOR THE COLORING PROCESS.

furnace, and another package is added, making now from 300 to 360 sheets or layers of metal one above another. Under the heavy hammers they go again, being beaten until they have spread out into a width of 12 to 13 centimeters, when they are finally annealed to restore their ductility. These metallic leaves are now knocked off, that is, they are divided in lengths of 90 centimeters. In consequence of these repeated annealings, a certain amount of oxidation would naturally take place upon the surface of the metal, and this must be removed by immersing the sheets in a dilute sulphuric acid bath. They are thus cleansed, and finally well brushed in clean water, rolled, and pickled, and bright-dipped in a tartar solution.

After the tartar bath they are again brushed with clean water, well rinsed, and finally dried quickly in heated chambers. After being treated in this manner the strips or ribbons are assembled in bunches of from 1,000 to 1,100 and, placed exactly one above the other, run under the finishing hammer until they reach a width of over 20 centimeters and a length of about 1 meter.

Two of these 1,000-sheet packets are now combined, and submitted to a renewed pounding by the finishing hammer until they have spread out to 24 centimeters in width, when the initial material for the manufacture of the bronze color seems to be ready, and under the name of ingot metal it is sold to the factories.

This so-called ingot metal consists of irregularly-formed thin sheets of brass possessing a high metallic gloss, and for the further manipulation they are cut or torn into small bits, and in this condition put into the stamps.

The stamps are air-tight boxes or cylinders in which the stamp rod rises and falls, lifted and released by a cam on a shaft turned by water or steam power. These stamps are arranged in a row, many of them driven by the same shaft, rising and falling alternately. To avoid falling always upon the same spot, a spiral or circular motion is imparted to the hammer rod at each stroke by gearing on the main shaft. The metal is crushed into powder in these stamps, and after passing through three of them, each set for a different degree of fineness, the powder is removed to the mills (called Steigmühlen) or rotating sheet-iron cylinders, where, by means of a peculiar motion, the metal powder is whirled around. The "steig" mills are provided with small receivers at different heights of the rotating cylinder, which serve to catch the powder according to its degree of fineness, the finest always going to the top, thus accomplishing the grading in a very simple manner.

The amount of metal which the individual stamps and the "steig" mills can accommodate is small, ranging from one to two kilogrammes. From this we see that a great number of these must be at hand to constitute a bronze-color factory of only modest dimensions. The coarser grades of bronze colors, that is, the cheaper sorts, are polished in a polishing mill. These polishing mills are closed cylindrical devices, in which rotating brushes dash the dusty bronze powder against the ribs inside, and thus impart to them a high gloss. The finer grades of bronze colors are subjected to further manipulation, by being mixed with a solution of gum Arabic upon a rubbing machine, consisting of several rollers, which roll in a circle over a flat table and turn at the same time about their own axes. These rollers may be adjusted to different positions radially from the center. The powder is subjected to the grinding effects of this chaser for several hours, whereby the finest possible division of the material is effected. If five parts by weight of dextrine and one part by weight of alum be substituted in the place of the gum Arabic while running the powder through the chaser after it is washed out in water, and the powder dried and polished, a very beautiful and cheap product may be realized. The yellow or white brocade after coming from the finishing stamps is placed in a rubbing machine. For this purpose a revolving tumbler of dish shape, containing heavy and freely-moving iron balls, is best adapted. This must be hermetically closed, and after a certain amount of benzine has been poured in, started and allowed to run for several hours. From this machine the powdered mass is now poured into a large dish, fixed upon a rocking mechanism, where it is rocked for several hours, and then allowed time to settle.

The benzine is now decanted from the top, and the bronze, which has settled in layers according to its fineness, may be partially skimmed off, dried at a heat of about 150 deg. C. and polished. The final stage in the preparation of these metallic powders is of course the coloring, which is attained through the tempering process. Whenever a single metal or an alloy of several metals is reduced to a finely-powdered state, the question often arises how to change the white or yellow cast to a desired tint which shall correspond more nearly to the end in view.

It is well known that, if a clean rod of copper, iron, brass, or German silver be heated, particularly if such a rod has been exposed to the air for a time, beautiful colors form upon its surface. These we call annealing colors.

The shades of the color may be best determined in advance, if a certain amount of the metallic powder be placed in a strong well-stoppered flask, with also a predetermined amount of sulphureted hydrogen gas, and shaken often and well. A well-corked flask will of course prevent the escape of the gas.

After twenty-four hours, or even longer, of this treatment, pour the dampened powder out in the open air upon a thick cloth and cover it over. The excess of water drips away, and by spreading it out and pressing it, the drying may be greatly accelerated, even in the open air and at ordinary temperatures. Now heat the powder in a clean sheet-iron or copper pan, which floats upon hot oil contained in a larger vessel, until the desired tint appears. This last is a very important part of the whole operation, and must be closely watched. Perfection and certainty can only be obtained by long practice, for the tint varies, first according to the composition of the alloy, and again it depends upon the amount of sulphurizing. In practice the oxidation colors are produced in this wise: The bronze powder is heated in an open copper vessel under a hood to carry off the fumes, as shown in Fig. 5, and some vinegar is mixed with the oil. By means of the variation in the temperature, the desired color or tone is reached, but the evenness of the coloring and the ability to obtain always the same color are dependent altogether upon the skillfulness of the oper-

ator. We shall postpone the consideration of the artificial coloring to some more convenient time. For the production of the silver bronzes—the aluminium, genuine gold and silver bronzes—we do not begin with the bullion itself, but the respective metals are cast into bars, rolled into strips, cut in small squares, and beaten in forms, just like leaf metal, with the hand. The material thus obtained is then ground in the same mills as the gold bronze powder, made finer in the "steig" mills, and run through other mills and chasers for finishing.

We give below further directions for the making of metallic powders. To produce a bronze powder of the color of brass, we proceed as follows: Subject the ordinary zinc dust of commerce, first of all, to a thorough chemical or mechanical cleansing, for the purpose of removing to the utmost degree any active oxidizing agents. Immerse it then in a brass-plating bath, consisting of an ammoniacal solution of cupric and zinc cyanide, in proportions to suit, according as one desires a more or less red or yellow tone.

The compositions of such brass-plating baths are well known. It is mainly important to keep the particles in the bath in an even and constant motion, which is best effected by the application of some mechanical means of stirring.

From time to time test samples must be taken out, in order to determine the thickness and quality of the coating. This is shown either by rubbing the powder upon a piece of glass with the polishing iron, or subjecting it to treatment with an acid solution of known concentration, in order to learn of what resistance the coating is capable. Having become satisfied that the thickness of the enveloping shell is sufficient, the product must be washed several times in water and dried. Should the zinc powder have been previously polished by mechanical means, only a very slight polishing will be needed by the product prepared as above; if, on the contrary, the powder shall have been cleansed only chemically, then it must be subjected to the bath as above detailed, and still stands in need of a severe polishing in the polishing mill or in any other suitable and convenient way.

In a similar manner, through the employment of other metallic baths, a whole series of different-colored metallic powders may be produced, of which the inner core consists of zinc covered by a shell or envelope of any electro-positive metal whatever. Moreover, it is also possible to impart to the envelope, by a second treatment, either electrolytically or by the annealing process, any desired tint or color, as we have done with the ordinary bronze-color powders.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Der Stein der Weisen.

THE ARTIFICIAL PRODUCTION OF RUBIES.

To the numerous experiments in synthesis, conducted either by dry or wet processes, which permitted Ebelmen, de Senarmont, Sainte-Claire-Deville, Hautefeuille, Frémy, Verneuil, and others to reproduce corundum, there has been recently added a new method that has the advantage over the preceding of affording stones capable of being employed in jewelry. We give here the broad lines of this method, which is to be published in the Annales de Chimie et de Physique with all the details that are necessary to permit the jewelry industry making use of it.

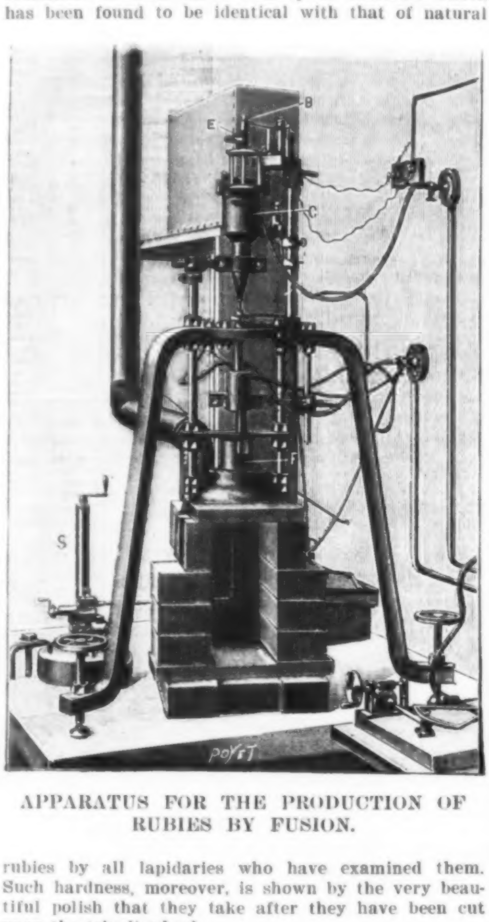
The inventor of this new process, which consists in first fusing the ruby by means of the oxyhydrogen blowpipe and then crystallizing it slowly in order to cause it to preserve its transparency, established the fact by his preliminary researches that the conditions that should be realized in order to permit of obtaining transparent crystallized rubies by fusion may be briefly summed up thus: (1) The fusion should be effected by always utilizing that part of the flame which is richest in hydrogen and carbon in order to prevent a bubbling that would interfere with the perfect refining; (2) the increase of the mass should be produced by layers superposed from the bottom upwardly, in order to effect the refining upon a series of thin layers, and also to effect a gradual solidification that shall allow the product to remain transparent; (3) the fusion should be effected under conditions such that the contact of the fused product with the support shall be limited to an extremely small surface, in order to reduce to a minimum the number of fractures, which become subdivided and render the product non-utilizable when the surface of contact of the molten ruby with every wall is not reduced to one point.

These three conditions are obtained by means of an apparatus of which a general view is given in the accompanying figure. In this figure, the screw support, *S*, to the left, permits of moving the molten mass to a distance by lowering it in measure as the proper zone of fusion becomes more distant from the end of the blowpipe, and when, during the course of the work, it becomes necessary to increase the pressure of the oxygen in the apparatus.

The refining by successive thin layers is obtained by means of a process that constitutes the most original part of the method, and which consists in drawing the powder of alumina mixed with oxide of chromium, or else the pulverized natural ruby, designed to be submitted to fusion, into the current of oxygen that supplies the blow-pipe.

These materials, contained in a wire-cloth basket placed in the chamber, *C*, are sifted by the slight impacts of the hammer, *B*, upon the anvil, *E*, that forms the top of the basket; and the powder, carried along in the central tube of the blow-pipe, becomes distributed through the flame and undergoes fusion therein as soon as it reaches a support formed of a thin stick of alumina placed in the center of the furnace, *F*. This powder, falling upon the alumina previously raised to a white heat, becomes agglomerated thereon, forming a cone, the point of which gradually rises until it reaches a zone of the flame hot enough to cause it to undergo fusion and form a filament that realizes the third condition enunciated above. If, now, the pressure of the oxygen be increased, this filament will be converted at its apex into a sphere, the diameter of which it will suffice gradually to increase up to the extreme limits that the heat of the blow-pipe is capable of reaching. Under such conditions, it is possible in three hours, by means of a blow-pipe with a nozzle 2.2 millimeters in diameter, to produce an ovoid mass of from 2 to 3 grammes' weight (say from 10 to 15 carats), which divides exactly into two parts, according to a vertical plane, when the primitive point is sufficiently fine and the mass in fusion has been very regularly heated. Each of these parts may be now cut according to the ordinary processes employed by lapidaries.

The chemical properties of these rubies are evidently identical with those of natural ones, their composition is the same, and they present the same resistance to reagents. When they are examined from a physical viewpoint, it is found that their magnificent red fluorescence is identical with that exhibited by the natural stone. They exhibit also the same luminescence when they are brayed or are submitted to energetic friction. Their density, which confirms the identity, is 4.01. Their hardness, estimated by their resistance to wear on the emery or diamond wheel, has been found to be identical with that of natural



APPARATUS FOR THE PRODUCTION OF RUBIES BY FUSION.

rubies by all lapidaries who have examined them. Such hardness, moreover, is shown by the very beautiful polish that they take after they have been cut upon the tripoli wheel.

Finally, their color equals that of the finest rubies of the East, when the alumina employed has been carefully purified and the chromium oxide has been properly proportioned. A crystallographic study of these artificial rubies also demonstrates the identity of their structure with that of the natural stones, and, as regards their optical properties, not a fragment of one of them could be distinguished from a stone cut from a natural crystal. It results from this that, from a chemical, physical, and crystallographic standpoint, there is an identity of properties and molecular structure between the artificial and natural ruby, and that this process of fusion, from a scientific viewpoint, affords a true synthesis of the stone under consideration.

But the identity of the natural product no longer exists as a general thing when the examination is directed to a mass of several carats instead of to an exceptionally selected parcel. In fact, it is but rarely that it has been possible to obtain stones that, after being cut, weighed a quarter of a carat, and that were entirely free from the two defects that up to the present characterize artificial rubies. These two defects, which are especially sensible in the large stones, consist of fine bubbles that are visible in the microscope and of striæ of discoloration due to a volatilization of the chromium oxide when the operation has not been sufficiently regular. But it is very probable that by making use of more powerful and perfect apparatus it will soon be possible to produce homogeneous rubies of several carats' weight, while up to the present none has been obtained weighing more than a grain. It is well to add that although the two defects already mentioned may allow experts to recognize the artificial rubies, the bubbles and striæ, which are visible only upon a scientific examination, in nowise detract anything from the luster and beauty of these artificial stones when the latter are the result of a well-conducted manufacture. In reality, such defects are imperceptible when the mounted rubies are examined under ordinary conditions and at some distance; and the limpidity of the latter by far exceeds the average transparency exhibited by the natural striæ, which also exist but very rarely in a perfect state. There is, therefore, reason to hope that after these artificial rubies come to be appreciated at their just value, the researches under consideration will put within reach of most people a stone as beautiful and durable as the natural ruby itself, which has hitherto been reserved for a privileged few.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE STEEL-HARDENING METALS.*

By JOSEPH HYDE PRATT.

THERE are included under the head of steel-hardening metals, nickel and cobalt, chromium, tungsten, molybdenum, vanadium, titanium, and uranium, which are named in the order of the importance of their production and use for steel-hardening purposes.

The special steels resulting from these additions vary among themselves, having individual properties of tensile strength and elastic limit, of conductivity, heat and electricity, of magnetic capacity and of resistance to impact, whether as shell or as armor plate. It was only about twenty years ago that the first of these metals, nickel, began to be used to any extent for the purpose of hardening steel, but since their introduction their use for this purpose has continued to increase steadily. Experiments are still being carried on with some of these metals in order to determine their actual commercial value with regard to the qualities that they impart to steel. In the arts it is the ferro-alloy of these various metals that is first prepared and is then introduced in the required quantity into the manufactured steel, but this ferro-alloy is never added to the molten mass during the manufacture of the steel. All these metals give characteristic and distinct properties to steel, but in all cases the principal quality is the increase in the hardness and the toughness of the resulting steel. Some of the metals, as nickel, chromium, and tungsten, are now entirely beyond the experimental stage and are well established in the commercial world as definite steel-hardening metals, and new uses are being constantly devised for the different steels, which are causing a constant increase in their production. Others, as molybdenum and vanadium, though they have been proved to give certain positive values to steel, have not been utilized to any large extent as yet in the manufacture of molybdenum or vanadium steel, partly on account of the high cost of the ores containing these metals. Titanium and uranium are still in the experimental stage; and, although a good deal has been written as to the value of titanium as an alloy with steel, there is at the present time very little if any of it used in the manufacture of a commercial steel.

Since the introduction of the electric furnace and the consequent methods that have been devised for reducing ores, it has become possible to obtain these ferro-alloys directly from the ores by reducing them in the electric furnace, and hence experiments have been conducted on a much larger scale than formerly.

MANGANESE STEEL.

Besides the use of ferromanganese for the chemical effect which it produces in the manufacture of steel in eliminating injurious substances, it is also used in the production of a special steel which possesses to a considerable degree combined hardness and toughness. Such steel contains from 0.8 to $1\frac{1}{4}$ per cent of carbon and about 12 per cent of manganese and is known as "Hadfield manganese steel." If only 1.5 per cent of manganese is added, the steel is very brittle, and the further addition increases this brittleness until the quantity of manganese has reached 4 to 5.5 per cent, when the steel can be pulverized under the hammer. With a further increase, however, of the quantity of manganese, the steel becomes ductile and very hard, reaching its maximum degree of these qualities with 12 per cent of manganese. The ductility of the steel is brought out by sudden cooling, a process the opposite of that used for carbon steel. These properties of manganese steel make it especially adapted for use in the manufacture of rock-crushing machinery, safes, and mine car wheels.

NICKEL STEEL.

Nickel finds its largest use in the manufacture of special nickel and nickel-chromium steels, and the use of these steels for various purposes in the arts is constantly increasing. The greatest quantity of nickel steel is used in the manufacture of armor plate, either with or without the addition of chromium. There is probably no armor or protective deck-plate made which does not contain from 3 up to 5 per cent of nickel. Nickel steel is also used for the manufacture of ammunition hoists, communication tubes, and turrets on battleships, and for gun shields and armor.

The properties of nickel steel or nickel-chromium steel that make it especially adapted for these purposes are its hardness and great tensile strength, combined with great ductility and a very high limit of elasticity. One of the strongest points in favor of a

* From a paper in "Mineral Resources of the United States," issued by the U. S. Geological Survey, 1904.

nickel steel armor plate is that when it is perforated by a projectile it does not crack. The Krupp steel, which represents in composition about the universal armor-plate steel, contains, approximately, 3.5 per cent of nickel, 1.5 per cent of chromium, and 0.25 per cent of carbon.

Another use for nickel steel that is gradually increasing is the manufacture of nickel steel rails. During 1903 there were over 11,000 tons of these rails manufactured, which were used by the Pennsylvania, the Baltimore & Ohio, the New York Central, the Bessemer & Lake Erie, the Erie, and the Chesapeake & Ohio railroads. These orders for nickel steel rails resulted from the comparison of nickel steel and carbon-steel rails in their resistance to wear during the five months' trial of the nickel steel rails that were used on the Horseshoe Cuwe of the Pennsylvania Railroad. The advantages that are claimed for the nickel steel rail are its increased resistance to abrasion and its higher elastic limit, which increases the value of the rail as a girder. On sharp curves it has been estimated that a nickel steel rail will outlast four ordinary rails.

Nickel steel has also been largely adopted for forgings in large engines, particularly marine engines, and it is understood that this is now the standard material for this purpose in the United States navy. There is a very great variety of these forgings and drop forgings, which include the axle and certain other parts of automobiles, shafting and crankshafts for government and merchant marine engines and stationary engines, for locomotive forgings, the last including axles, connecting rods, piston-rods, crank-pins, link-pins, and pedestal cap bolts, and for sea-water pumps.

Another important application that is being tried with nickel steel is in the manufacture of wire cables, and during the last year such cables have been made by the American Steel and Wire Company, but no comparison can as yet be made between them and the ordinary carbon-steel cables with respect to their wearing qualities.

In the manufacture of electrical apparatus nickel steel is beginning to be used in considerable quantity. The properties of this steel which make it especially valuable for such uses are, first, its high tensile strength and elastic limit, and, second, its high permeability at high inductions. Thus steel containing from 3 to 4 per cent of nickel has a lower permeability at low inductions than a steel without the nickel, but at the higher inductions the permeability is higher. A notable instance of the use of this material is in the field rings of the 5,000-horse-power generators built by the Westinghouse Electric and Manufacturing Company for the Niagara Falls Power Company. These field rings require very high tensile strength and elastic limit, and in order to reduce the quantity it is desirable that they have high permeability at high inductions. This result was secured by using a nickel steel containing approximately 3.75 per cent of nickel. Steel containing approximately 25 per cent of nickel is nonmagnetic and has a very low resistance temperature coefficient. This property is occasionally of value where a non-magnetic material of very high tensile strength is required. The high electrical resistance of nickel steel of this quality, together with its low-temperature coefficient, makes it valuable for electrical resistance work where a small change in the resistance due to change in temperature is desirable. The main objection to using nickel steel for this purpose is the mechanical defects that are often found in wire that is drawn for this quality of nickel steel.

For rock drills and other rock-working machinery nickel steel is used in the manufacture of the forgings which are subjected to repeated and violent shocks. The nickel content of the steel used in these forgings is approximately 3 per cent, with about 0.40 per cent of carbon. The rock drills or bits are made for the most part of ordinary crucible cast steel which has been hardened and tempered. There is a field for investigation here in respect to the value of some of the special drills in the manufacture of rock-drill steels or bits. A nickel-chrome steel is now being made which is used to some extent in the manufacture of tools.

Nickel steel in the form of wire has been used quite extensively and for many purposes—for wet mines, torpedo defense netting, electric lamp wire, umbrella wire, corset wire, etc.—where a non-corrosive wire is especially desired. When a low coefficient of expansion is desired—as in the manufacture of armored glass, in the mounting of lenses, mirrors, lever tubes, balances for clocks, weighing machines, etc.—nickel steel gives good satisfaction. For special springs, both in the form of wire and flats, a high carbon nickel steel has been introduced to a considerable extent. Nickel steel is also being used in the manufacture of dies and shoes for stamp mills, for cutlery, table ware, harness mountings, etc.

Nickel steels containing from 25 to 30 per cent nickel are used abroad to some considerable extent for boiler and condenser tubes and are now being introduced into this country. The striking characteristic of these steels is their resistance to corrosion either by fresh, salt, or acid waters, by heat, and by superheated steam. The first commercial manufacture of high nickel-steel tubes began in France in 1898, and was followed in Germany in 1899; but it was not until February, 1903, that these tubes were made in the United States. Since then, however, Mr. Albert Ladd Colby states:

"The difficulties of their manufacture have been so thoroughly overcome that the 30 per cent nickel steel, seamless, cold-drawn marine boiler tubes, now a commercial proposition, are made in practically the same number of operations, and with but a slightly greater percentage of discard than customary in the manufacture of ordinary seamless tubes, and, furthermore, the finished 30 per cent nickel steel tube will stand all the manipulating tests contained in the specifications of the Bureau of Steam Engineering, United States Navy Department, for the acceptance of the carbon-steel seamless cold-drawn marine boiler tubes now in use. In addition, the nickel-steel tubes have a much greater tensile strength."

Although the first cost of the nickel-steel tubes for marine boilers is considerably in excess of the carbon-steel tubes, yet, on account of the longer life of the nickel-steel tubes, they are in the end cheaper than the others. At the present time 30 per cent nickel-steel tubes cost from 35 cents to 40 cents per pound, as compared with 12 cents to 15 cents per pound for the corresponding mild carbon-steel tubes. Thus their initial cost, when used in the boilers of torpedo boat destroyers, is 2.13 times as great as the other kind and 2.43 times as great when used in the boilers of battleships, but the nickel-steel tubes will last two and one-third times longer than those made of the carbon steel, and when finally taken from the boilers they can be sold not only for the market price of steel-tubing scrap, but also at an additional price of 20 cents per pound for their nickel content. Thus it is seen that 30 per cent nickel-steel boiler tubes are really more economical to purchase than carbon-steel boiler tubes.

In addition to marine boilers, high nickel-steel tubes can be used to advantage for stationary boilers, automatic boilers, and locomotive safe ends. It is the higher elastic limit of the 30 per cent nickel-steel boiler tubing that will prevent the leaks that are constantly being formed where the mild carbon-steel tube is used. The leaks are due to the expansion of the flue-sheets when heated, which compress the tubes at the points where they pass through the fluesheets, and cause in the case of the mild carbon-steel tube a permanent deformation. This results in the leakage and necessitates the frequent expanding of the tubes. In the high nickel-steel tubes this difficulty is overcome by their higher elastic limit. This deformation and the resulting leakage are especially true of locomotive boilers. For automobile tubular boilers a 23 to 25 per cent nickel-steel tubing is used, each coiled section being made from one long piece of nickel-steel tubing, which, by a special heat treatment, is enabled to withstand this bending without cracking.

Nickel-steel tubing containing 12 per cent of nickel has been used by the French since 1898 in the manufacture of axles, brake beams, and carriage transoms for field artillery wagons, and the desired result in the reduction of weight has been obtained without loss and without stiffness of the wagons. A 5 per cent nickel-steel tubing has been used in the manufacture of bicycles since 1896.

CHROMIUM STEEL.

The largest use of chromium is in the manufacture of a ferro-chromium alloy which is used in the manufacture of a chrome steel. In the manufacture of armor plate ferro-chrome plays a very important part, and, although it is sometimes used alone for giving toughness and hardness to the armor plate, it is more commonly used in combination with nickel, making a nickel-chromium-steel armor plate. Other uses of chrome steel are in connection with five-ply welded chrome steel and iron plates for burglar-proof vaults, safes, etc., and for castings that are to be subjected to unusually severe service, such as battery shoes and dies, wearing plates for stone crushers, etc. A higher chromium steel which is free from manganese will resist oxidation and the corrosive action of steam, fire, water, etc., to a considerable extent, and these properties make it valuable in the manufacture of boiler tubes. Chromium steel is also used to some extent as a tool steel, but for high-speed tools it is being largely replaced by tungsten steel, which seems to be especially adapted to this purpose.

The percentage of chromium that is used in the chromium steels varies from 2.5 to about 5 per cent and the carbon from 0.8 to 2 per cent. The hardness, toughness and stiffness which are obtained in chromium steel are very essential qualities, and are what make this steel especially beneficial for the manufacture of armor-piercing projectiles as well as of armor plate. For projectiles chromium steel has thus far given better satisfaction than any of the other special steels, and is practically the only steel that is used for this purpose. The value of chromium steel for this purpose is well brought out by Mr. R. A. Hadfield, manager of the Hecla Works, Sheffield, England, who states that a 6-inch armor-piercing shot made by this firm was fired at a 9-inch compound plate, which it perforated unbroken. It was then fired again from the same gun and perforated a second plate of the same thickness, the shot still remaining unbroken.

TUNGSTEN STEEL.

Tungsten steel is used to some extent more generally abroad than in the United States, in the manufacture of armor plate and armor-piercing projectiles. For this purpose it is used in combination either with nickel or chromium, or with both of these metals. The use for which tungsten steel seems to be best adapted is in the manufacture of high-speed tools and magnet steels. The property that tungsten imparts to the steel is that of hardening in the air after forging and without recourse to the usual methods of tempering, such as immersion in oil, water, or some special solution. For high-speed tools tungsten steel is especially adapted, as it retains its hardness and cutting edge even at the temperature developed in the use of these high-speed tools. The value of tungsten steel for permanent magnets is on account of its retaining comparatively strong magnetism and of the permanence of this magnetism in the steel. This property makes the tungsten steel particularly desirable in instrument work where the calibration of the instrument depends upon the permanence of the magnet used. For compass needles tungsten steel has been used by W. and L. E. Gurley with entire satisfaction.

MOLYBDENUM.

The use of molybdenum steel continues to increase, and hence there is an increasing demand for the ores of this metal. The main use of ferromolybdenum is in the manufacture of tool steel. The properties which molybdenum gives to steel are very similar to those given by tungsten, the main difference being that it requires a smaller quantity of molybdenum than of tungsten to acquire the same results. Ferromolybdenum is produced, like ferrotungsten, by reducing it from the ore in an electric furnace. There are now two molybdenum-nickel alloys being produced, one of which contains 75 per cent molybdenum and 25 per cent nickel, and the other 50 per cent molybdenum and 50 per cent nickel. Besides these constituents the alloy contains from 2 to 2.5 per cent iron, 1 to 1.5 per cent carbon, and 0.25 to 0.50 per cent silicon. The molybdenum steel which is made from these alloys is recommended for large cranks and propeller-shaft forgings, for large guns, rifle barrels, and for wiring and for boiler plates. The molybdenum increases the elongation of steel very considerably, and for wire drawing such an increase at a comparatively small cost is important.

VANADIUM STEEL.

On account of the extremely high price and scarcity of vanadium ores, the metal has thus far been employed very little in the manufacture of ferrovanadium for use in the production of vanadium steel. It is claimed by many that the beneficial properties imparted to steel by vanadium exceed those of any of the other steel hardening metals. These are exaggerated statements, but it may be found that smaller quantities of vanadium will give in some cases the same results that are obtained by comparatively large quantities of the other metals. One property claimed for vanadium steel is that it acquires its maximum of hardness not by sudden cooling, but by annealing at a temperature of from 1,300 to 1,470 deg. F. This property would be particularly advantageous for high-speed tool steel and for points of projectiles. There is, however, at the present time little or no vanadium steel on the market.

TITANIUM.

The actual commercial value of titanium as a steel-hardening metal has not been thoroughly demonstrated. Experiments have shown that from 0.5 to 3 per cent of titanium increases the transverse strength and the tensile strength of steel to a very remarkable degree. Until the development of the electric furnace it was practically impossible to produce either titanium or an alloy of iron and titanium, but since the introduction of this furnace ferrotitanium can be produced directly from the ores. It is to the manufacture of a special cast iron that ferrotitanium seems to be especially adapted. The titanium in the iron gives greater density to the metal, greatly increases its transverse strength, and gives a harder chill or wearing quality to a wheel made from such an iron. For the manufacture of car wheels it would seem that the titanium iron would be especially useful.

DISTANCE CONTROL BY ELECTRIC WAVES.

WIRELESS telegraphy embodies the simplest application of induction effects due to electric sparks, resulting in the repeated attraction of an electromagnetic contact, the intervals being so controlled as to indicate the various signals to be transmitted. Now Prof. E. D. Branly has endeavored, by the aid of electric waves, to attain at the receiving station several other effects without the interference of an operator at that station.

An experimental apparatus, which was recently presented by the inventor to the French Academy of Sciences, operates with perfect regularity in a laboratory, so that an extension of its range to that of practical wireless telegraphy would seem to be quite feasible. The following three effects have been more especially studied: Starting an electric motor; causing incandescent lamps to glow; causing an explosion.

All these effects can be produced or discontinued in any desired order, one after the other. It should, however, distinctly be understood that they have been chosen quite arbitrarily, and that any other mechanical action, or in fact a series of actions depending on one another (constituting, for instance, the working of a complicated machine) could be brought about or discontinued quite as well.

The distributor of the action in question consists of an insulated shaft on which are mounted some metal disks, rubbing against brushes and springs to allow the electric current to pass. The shaft is driven by a clockwork, and each disk is obviously an interrupter that corresponds with some special phenomenon it is able to produce or to discontinue, and which is determined by its shape.

Choosing as an example a disk to be employed in the lighting of incandescent lamps, the edge of this disk strikes constantly against a brush. On the disk's circumference there is a sector of about 90 deg., having a radius somewhat greater than the remaining cir-

cumference. This sector presses against a spring rod, and by this pressure effects the closure of what might be called the lamp-lighting circuit, provided the relay connected with the coherer (or any other radio-conductor) begins to act. To this effect a spark should be produced at the sending station for the fraction of a revolution, during which the pressure is exerted, whereupon the incandescence of the lamp will be kept up by virtue of the action of an electromagnet, though the relay has worked only for a moment. This incandescence is accordingly protected against any influence on the part of the sparks at the sending station, and spark from the sending station will light or extinguish the lamps at the receiving station, while between the signals 2 and 3 the motors will be started or stopped, and between 3 and 1 the explosion will occur.

The signals are due to the temporary closing of the circuit of an induction coil, placed at the receiving station, and this closing in its turn is produced by three teeth of different shape of the disk, which teeth are inserted between the sectors in the projected periphery.

The radio-conductor and its tipper, the relay as well as any accessories, are inclosed in a cage made from

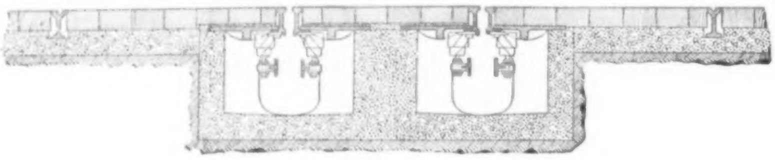


FIG. 1.

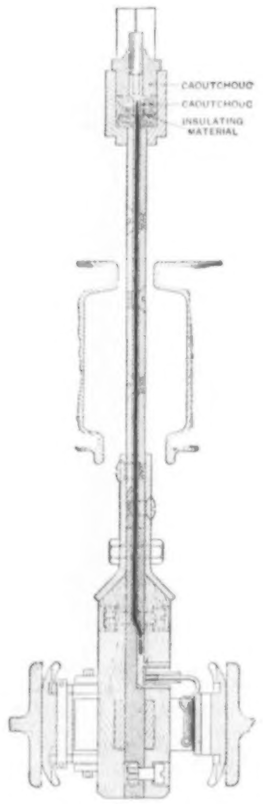


FIG. 2.

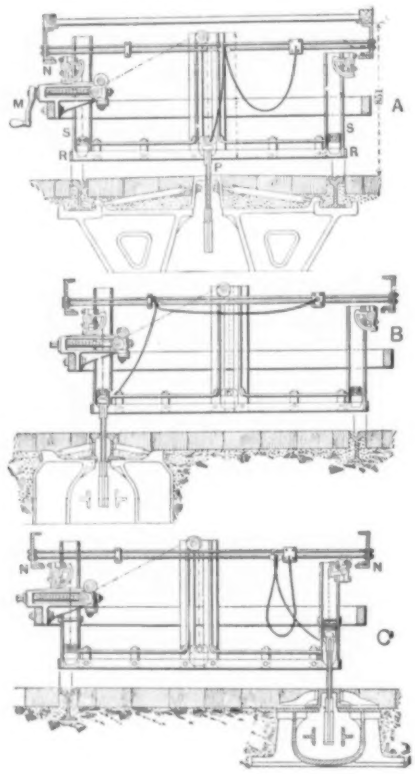


FIG. 3.

DETAILS OF THE NEW PARISIAN CONDUIT LINE.

is discontinued only if a spark be produced there, while the disk once more closes the lighting circuit by pressure.

For the three actions above enumerated, there are three disks provided, each of which has a sector of about 90 deg., contacting one after the other with the corresponding spring rods. A spark from the sending station can produce the closing of any one of the three circuits.

The official at the sending station knows that he is in a position to act on such and such a circuit from the inspection of the tape of a Morse apparatus, including a radio-conductor; this tape is unwound before his eyes, and receives a signal from the receiving station during the three short intervals of 20 deg. separating the sectors on the complete periphery. These intervals are always free from any contact with the spring rod.

In the interval, e. g., between the signals 1 and 2, a metal grating, and which affords protection against induction due to sparks produced in their neighborhood. At the moment the sparks are produced, the antenna is by the movement of the shaft connected with the coil, while passing to the radio-conductor circuit, during the interval the sectors are pressing on spring rods.

Though the radio-conductor used by the inventor is a tripod disk and quite safe in working, means have been provided to check its action, ascertaining whether the effect required has really taken place at the receiving station. To this end another disk fitted with a single tooth has been reserved for each special action at intervals of 30 deg., corresponding with the signals for indicating the position of the sectors. By the aid of the coil this tooth will give a signal that is inserted in the most suitable interval, and which lasts with each revolution as long as the corresponding phenomenon has not disappeared.

A NOVEL CONDUIT LINE.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

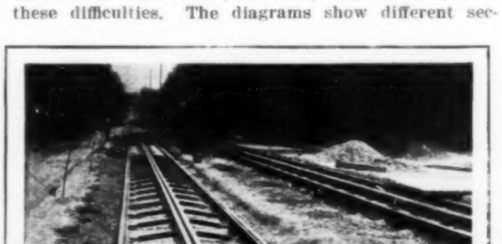
PARIS has a number of underground conduit electric lines which have been running very successfully for several years past. The first conduit line to be laid in the city forms part of the electric road which starts from the Place de la Bastille and runs to the eastern suburbs as far as Charenton. The total length of this line is 3.5 miles, of which 1.5 miles lie in the city and two miles in the suburbs. The underground conduit is laid for a part of the distance, while for the remainder the cars use a trolley and an overhead wire. The conduit portion starts from the Place de la Bastille and runs for a length of 0.52 mile. The road was laid out with the intention of using light cars which should run at frequent intervals, contrary to the usual practice in Paris, heretofore, where a heavy type of car was generally employed on the mechanical traction systems. At the same time special care was taken to make the part of the trolley line which passes along some of the main avenues as handsome in construction as possible, so as to overcome the objections which had been made to the use of the trolley within the city limits. With this end in view ornamental iron poles were placed at intervals between the two tracks. These poles serve to hold the trolley wire by side brackets and at the same time support an arc lamp for lighting the avenues.

A few years later a second conduit system was constructed which covers a considerable length within the city. Like the former it has been installed by the Paris branch of the Thomson-Houston Company. All the material for the line and cars has been manufactured in France. The new line runs from the Bastille, where it connects with the first-mentioned line, to the Montparnasse Depot, from whence the second section starts and continues to the northwest to the Place de l'Etoile. The third section runs from this point to the Place Pereire. The total length of the three sections, which form a continuous line, is some seven miles. The new conduit system replaces a traction line using horse omnibuses, over which there was considerable traffic. This has greatly increased since the establishment of the electric road; the latter is now one of the leading electric lines of the city, and it is to be ranked among the principal conduit lines of Europe.

While the Bastille-Charenton line which was first built adheres somewhat closely to the type of conduit which is used in America, at Washington, for instance, the new conduit road contains many features which make its construction a novel one, and one differing considerably from what has been employed heretofore. The engraving shows a section of the Bastille central slot conduit at the time of construction. It differs from the Washington system, however, in the method of supporting the contact rails carrying the current inside the conduit and also by the fact that the paving of the street is made to cover the conduit entirely, leaving but a small number of manholes. When it came to laying the new road over a long distance, it was found that the central slot conduit could not be introduced to a great extent owing to the use of wood paving on the avenues. The excessive wear of the latter would soon cause the conduit rail to project above the surface and thus hinder the vehicle traffic. The same inconvenience occurs in the track rails, but this cannot be avoided, while for the conduit it is possible to find another solution. Accordingly, it was decided to design a new system of conduit, placing the slot upon the side instead of in the center, and this led to a considerable modification of the internal design.

In the new system the slot is placed on the side along the running rail of the track. This gives rise to several difficulties, however. First, the obstruction of the groove by an accidental cause has a double disadvantage, seeing that the slot gives passage not only to the plow, but to the rim of the wheel. Again, the conduit has to support the direct weight of the vehicle, and must therefore be made stronger. It is more difficult to keep the inside of the conduit clean and the parts carrying the current well insulated, owing to the splashing of mud from the wheels. The new method of construction, however, overcomes most of these difficulties. The diagrams show different sec-

COMBINATION TRAIN ON THE BASTILLE-CHARENTON ROAD.



SECTION ON BASTILLE-CHARENTON ROAD.

THE NEW ELECTRIC CONDUIT LINE OF BASTILLE-CHARENTON.

tions of the conduit, the contact plow and the manner of supporting the same. The design of the new conduit system, in which the writer had the pleasure of assisting, was carried out at the Paris works of the company. In Fig. 1 is shown a section of the two conduits, one for each track. They are placed on the inner side of the track. The outer track rail is of the ordinary type, while the conduit rail serves as the inner track rail. Here the conduit rail is double and the space between the two rails gives passage to the plow which runs in the conduit. The conduit is formed by placing a series of cast iron supports or frames at regular intervals (see photograph) and bracing them together by side-bars. Between the frames are placed a series of sheet iron forms having the section of the conduit, and beton is filled around them. When the latter is fixed, the forms are drawn out through the slot. The wood paving of the street is then laid over the conduit. Fig. 1 is a section through a manhole, showing the contact bars which carry the current.

Where the road passes the bridge over the Seine, a special form of shallow conduit had to be used as there is not sufficient depth to place the standard form. Here the conduit is formed of cast iron sections about three feet long, reinforced by a web in the center. At the top is a steel plate on either side of the groove, upon which are fixed the conduit rails. The adoption of the shallow conduit made it necessary to elevate the conducting rails for the plow some five inches, and thus the plow had to be raised and lowered by a special device when passing over this point. The method of supporting the plow is one of the problems which needs to be solved in as satisfactory a manner as possible. On the long conduit lines in Europe such as at Berlin, Brussels, and Budapest, it is found that the best method is to keep the plow always attached to the car, and to provide a mechanical device for raising and lowering it when at the terminus of the line, without needing men in the manholes to accomplish this. In the above cities the slot is wide enough to allow the plow to be drawn out at any point of the line, but this gives an excessive width to the slot, and makes the plow of a narrow design which is not desirable. To carry out the present idea the plow has been designed as shown in Fig. 2. It consists of several iron plates bolted together, and supporting a pair of contact shoes by means of levers and springs. The current wire passes down the middle to the contact shoes.

Where the line changes over from conduit to trolley, the following method is used for raising the plow out of the conduit: The space provided underground is large. The slot is made to open and close at this point, and so allow the plow to be lifted out of the conduit. For this purpose, the slot runs between two trap doors supported on a cast iron frame lying flush with the pavement. The traps are opened by means of a mechanical device which the motorman operates by a lever. At the same time the motorman lifts up the plow by the device which is described below.

The method of lifting the plow formed one of the most difficult points in the design of the apparatus, as the following conditions had to be fulfilled: In some of the crossings the central conduit is used, and thus the plow is obliged to shift from the side to the center of the car while still in the conduit. Again, the plow is to be raised out of the conduit or lowered into it. This always takes place in the central conduit. Third, while in the side position, the plow is to be raised or lowered in passing from the standard depth conduit to the shallow conduit which is mentioned above. Fourth, at the places where the plow is lifted or lowered into the conduit, the electric circuits must be automatically established by the same movement which works the plow. These different operations are carried out by the device which is shown in the views *A*, *B*, and *C* of Fig. 3. The plow, *P*, is made to slide along the rail *R* by means of its two side arms, and it can thus move to and fro under the car. When in the middle position in the central conduit (*A*) it can be raised out of the conduit by means of a lifting device which the screw *M* at the side operates. The handle *M* lies on the side of the car and is removable. Fig *B* shows the plow in lateral conduit and under normal working conditions, while Fig. *C* shows it in the shallow conduit. In this case, when at either side of the car, the plow can be adjusted in height by another lifting device which is observed at *N*. The operation of the lifting device by the conductor also changes the electric connections by means of a switch which is connected to the former by a lever.

PRODUCER-GAS POWER PLANTS.*

By A. FREDERICK COLLINS.

THE operation of large gas-engine units in competition with those utilizing steam has been made possible by improved methods for economically converting all kinds of fuel, be it anthracite or bituminous coal, coke, lignite, peat, wood, and even rubbish, into a gaseous state.

The apparatus in which this conversion takes place is termed a gas producer, and its relation to the gas engine is equivalent to that of the boiler to the steam engine. The gas-producer plant and the steam boiler require about the same amount of attention, but the former, used in connection with its internal combustion engine, represents a much higher degree of efficiency than the latter, for the heat loss attendant upon the conversion of water into steam is eliminated, as well as that due to a long, leaky, high-temperature steam line.

Especially is the above true of small gas-engine units, and steam can only approximate the efficiency of gas where very large plants are practicable, as for instance in the operation of steam railways. This may be strikingly illustrated by a comparison of the consumption of fuels between these two types of prime movers. Thus the amount of fuel consumed under a steam boiler for an engine of, say, one hundred horse-power requires, under favorable conditions, from two and one-half to four pounds per horse-power per hour, as against a consumption of one pound of coal per horse-power per hour in a gas producer and engine having an equal output. In practice, however, the actual consumption of a gas plant, constructed in accordance with the most approved designs, is only one-fourth that of a steam plant of similar capacity.

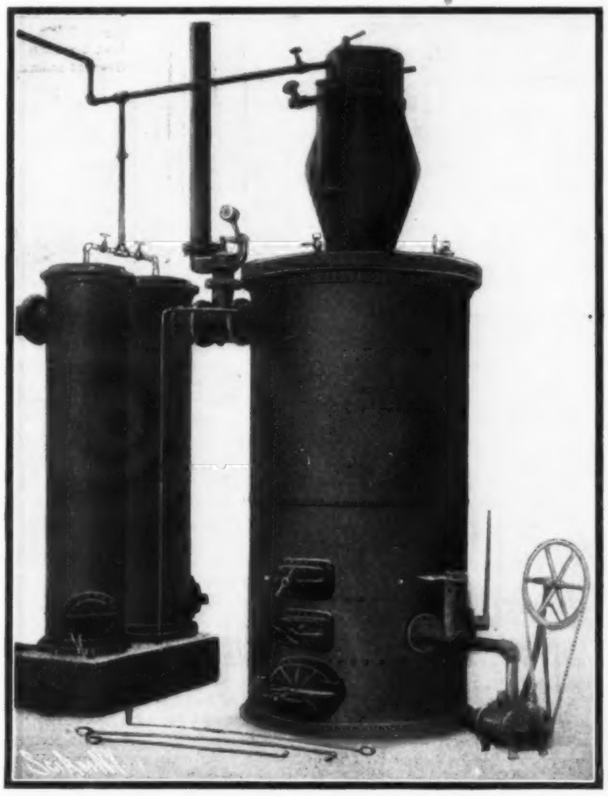


FIG. 5.—CROSSLEY GAS PRODUCER COMPLETE.

For this very excellent reason, as well as the subsidiary one that the gas producer is far less dangerous than the modern high-pressure steam boiler, the growth of the gas-producer and gas-engine industries has been remarkably active the last few years, and the future is full of promise for the new power *régime*, as the apparatus for the generation of gas is being constantly improved, and engines are being built in ever-increasing sizes.

In producer-gas power plants the equipments are constructed so that a combustible gas is obtained directly from the coal or other fuel, and this product is then washed to free it from impurities and cooled, when it is ready to be utilized in the cylinder of the gas engine. When this point is reached, air is mixed with it in the proper proportions, when it is compressed in the cylinder and ignited, either by the flame of a gas jet, by the electric spark, or, as in the Diesel engine, by means of a high temperature which is evolved during its cycle of operations by compression of the air, when the gas, coming in contact with it, is consequently ignited.

There are several forms of gas-producer systems, and these may be divided into two general classes, namely (*a*) those known as the *pressure* type and (*b*) those of the *suction* type. The characteristic difference between these two systems is that in the former air compressed by means of a fan or blower is projected through the bed of burning fuel in the generator, and serves not only as a blast for the fire, but forces the gas from the generator under pressure, and in this state it enters the cylinder of the engine. In this type of gas generator a gas holder is required to receive the gas to be used in the engine.

In the suction type of apparatus, the gas is generated by air, which is drawn or sucked through the fuel, saturator, and scrubber by the suction action of either an auxiliary pump, called an exhauster, or the piston of the engine itself. Since recent gas engineering practice has favored the suction system of producers, it is the purpose of this paper to describe two forms of the latter, the first using a gas holder, and the second operating the engine direct.

In the Loomis-Pettibone gas producer the air is drawn through the producers by the suction of the exhauster, shown in longitudinal section, Fig. 1, in the plan, Fig. 2, and in the photograph, Fig. 3. The air enters through the same doors in the top of the producers where the generator is charged with fuel. When the fresh air and fuel are drawn downward through the deep layers of white-hot fuel, the products of combustion and any distillates, or separated products, pass out through the grate of fire brick at the bottom of the producer.

The temperature of the gas as it comes from the generator is naturally very high, and this is utilized to generate steam in the boiler, through which the gas next passes, and when it issues from this, its tempera-

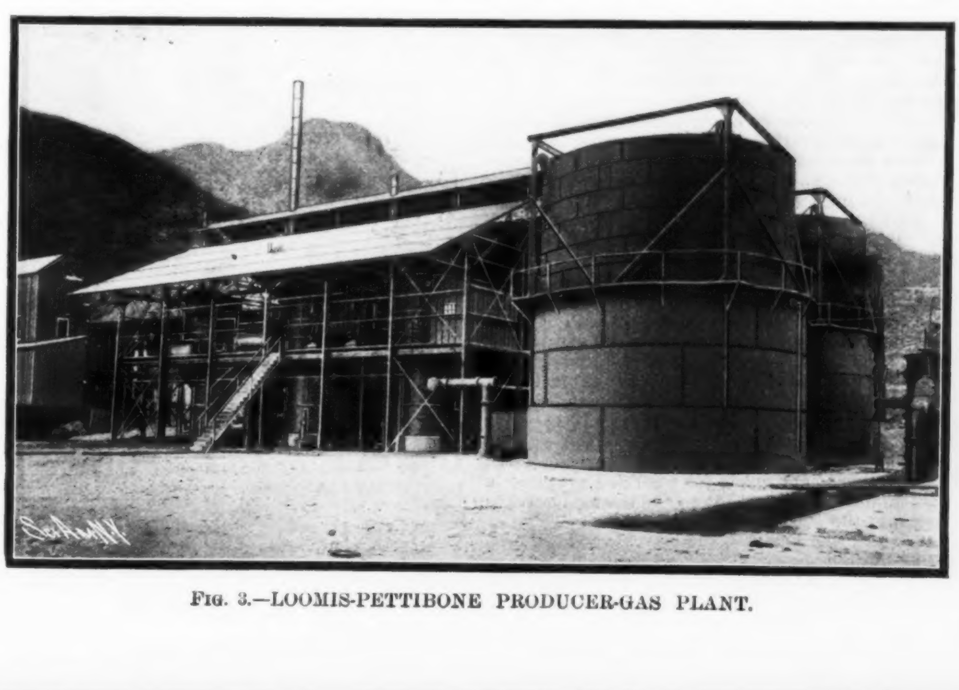


FIG. 3.—LOOMIS-PETTIBONE PRODUCER-GAS PLANT.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

ture is reduced to about that of ordinary chimney gas; passing from the boiler to the scrubber, consisting of trays filled with coke and sprayed with water, it is cooled to the normal temperature of atmospheric air, when it is finally forced by the exhauster into the gas holder.

The object of the steam boiler, which utilizes the high temperature of the gas that would otherwise be wasted, is to make water gas. To accomplish this, the feed doors are closed intermittently, as well as the valve, and steam is then admitted under the grate of generator No. 1 (Fig. 2) when it is separated into its constituent elements, forming water gas in its passage through producer No. 2, whence it is conducted by the valve, *A*, to the boiler, the scrubber, and finally to the gas holder. When water gas is again made, the process begins in No. 2, working through No. 1, so that the direction is reversed.

Two gas holders are employed to receive the producer gas and the water gas, the holder for the producer gas giving the necessary elastic storage between the apparatus generating the gas and the engine utilizing it. The second holder, which has only a third of the capacity of the first, is employed for the purpose of receiving and keeping separate the producer gas and the water gas thus intermittently generated. The valves, *X Y Z*, permit the gas to be delivered to either of the holders or escape into the air through the purge pipe.

These plants are operated with either kind of coal or with wood, whichever may be procured the most cheaply in the locality where the plant is set up; and the down draft principle, which is the chief feature of the suction system by which the gases are passed through the bottom of the fire, is highly efficient in producing fixed gases from any and all kinds of fuel.

Another form of suction gas producer, also manufactured by the Power and Mining Machinery Company, is a reproduction of an English system known as the Crossley. In this the gas is drawn through the fuel bed as before, thence through a saturator and a scrubber, and directly into the cylinder of the engine by the suction action of the piston. This arrangement, while available for the largest systems, also provides an economical solution for the problem of generating gas for small plants, for it will be observed that it does not require expensive gas holders, thus reducing appreciably the first cost.

In the American Crossley producer the plant comprises the following principal parts: the producer, the saturator, hydraulic box, coke scrubber, and sawdust scrubber. The producer is made of a cylindrical steel shell lined with fire brick and fitted with a revolving steel grate, all of which is shown in diagram, Fig. 4, and in the photograph, Fig. 5. There is an annular space between the brickwork and the outer shell, through which the air for the combustion of the fuel passes from the saturator to the bottom of the producer; a central collecting bell is suspended from the top, and keeps the fuel at a uniform level.

One or two charging hoppers are provided, either in the center or one on each side of the bell. The fuel is charged through tubes, and the hoppers are emptied alternately. The bottom of the producer is closed by a water seal, so that the cleaning and removal of ashes may take place without interrupting the continuous operation of the plant. The air and steam in passing through the incandescent fuel combine with the carbon in the formation of gas, which leaves the producer, *A*, through the central collecting bell when it passes on to the separator, *B*.

The saturator is a water-jacketed pipe, in which the water is maintained at a constant level. The gas as it passes from the producer is hot, and the saturator not only reduces the temperature, but the entering air in its passage through the producer comes in contact with the heated water, and picks up a certain amount of steam vapor, which on its course through the fire increases the calorific value of the gas there being formed.

Sometimes the saturator is omitted, the steam which this apparatus would supply for gas being produced in an evaporator attached to the top of the producer. In either case the gas is next directed into a hydraulic box, *C*, which acts as a seal, and prevents any gas from backing up into the producer. It is provided with an inclined water trough, which permits the removal of accumulated dust. The gas then enters a cylindrical steel shell, *D*, filled with coke, through which a small quantity of water trickles. This clears the gas of any tarry products that it may contain, and is cooled to atmospheric pressure.

After passing through another scrubber, *E*, having trays filled with sawdust or a similar material, which exposes the gas to a very large surface, and removes the last vestiges of fine ash or other solid matter which may have been carried over the gas, it is now perfectly clean, cool, and dry, and ready for work in the engine. Under some circumstances the sawdust scrubber is not necessary, the gas being sufficiently clear after leaving the coke scrubber for immediate use in the engine.

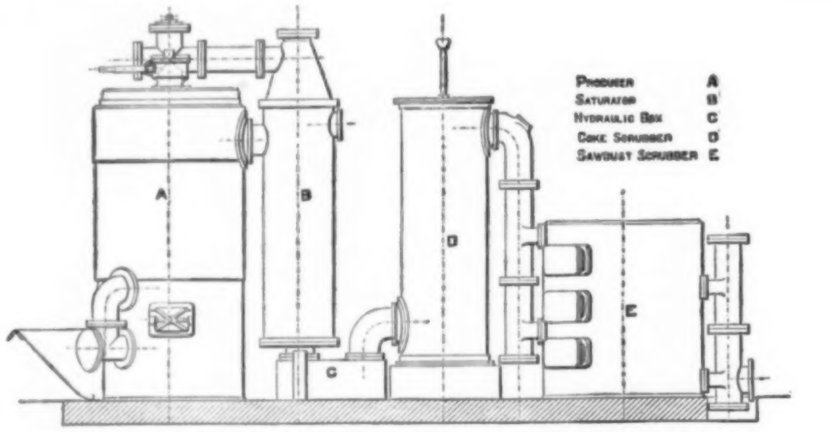


FIG. 4.—AMERICAN CROSSLEY SUCTION GAS PRODUCER.

In starting a plant, a small hand-fan is used to bring the fuel to incandescence; as soon as the gas is sufficiently rich to use in the engine, the operation of the producer becomes automatic. Small engines are usually started by giving the flywheel a turn or two by hand. The larger engines are started either with compressed air or with illuminating gas, and as soon as the engine has made one or two revolutions, it is allowed to take gas from the producer.

These suction gas plants are especially designed to render long and continuous service without repairs or stoppages for any reason. The Crossley type, just described, is built in units from 8 to 300 horse-power, and its simplicity, compactness, and economy are features which are attracting more attention to the gas engine to-day than to any other of the four great powers.

Gas-producer and engine plants are much more common in Europe than in America, in virtue of the fact that the cost of fuel for steam plants is almost prohibitive in many of the countries of the old world.

While large units are not so much in evidence in the United States, there are at the present time innumerable small engines using gasoline or illuminating gas for fuel. Clearly, the small consumer is not aware of the advantages, from an economical standpoint, of the gas producer, but the following comparison will indicate at once the handsome saving that can be effected by installing a suction plant and using anthracite coal, coke, or charcoal.

Gasoline, purchased by the barrel, costs about 15 cents per gallon, while coke can be purchased in almost any city or town for $4 per ton. Using these figures as a basis for comparison, and assuming that the plants are to develop 40 horse-power per hour for ten hours, and that one-eighth gallon of gasoline at 15 cents will produce one horse-power, 400 horse-power would cost $7.50; whereas one pound of coke will give one horse-power per hour, then at $4 per ton the cost would be 80 cents per day, or a saving of $6.70 per day in favor of the gas producer, or an annual saving of over $2,000.

Thousands of small manufacturers, electric lighting plants, etc., are using the crudest type of slide valve engines, which consume, even at a conservative estimate, from six to eight pounds of coal per horse-power hour; and a gas engine with a suction producer would prove a most remunerative substitute, and one showing a very large return on the investment.

Improvement in the Treatment of Viscose.—In the treatment of viscose (cellulose rendered soluble by the carbon bisulphide process, that of Cross and Bevan) it is gelatinized in a receiver. After coagulation and cooling, it is now subjected to a modified process by the Societé Française de la Viscose, consisting essentially in the simultaneous action of washing with a saline solution, and drying. It is necessary that the drying apparatus should consist of earthen ware on a metal not attacked by polysulphides, such as aluminium. The coagulated viscose is mixed immediately with a solution of sea salt, whether containing lime and magnesia or not, or with a mixture of sea salt and sodium bicarbonate, for example, for 100 kilogrammes of viscose having 10 per cent of cellulose, a solution of 100 liters of water containing 10 per cent of sea salt (sodium chloride) and 10 per cent of sodium bicarbonate. The pasty mass is put in the dryer, which at first expels the mother water. While the apparatus is at work a new saline solution having 50 per cent of sodium chloride is introduced in less or greater quantity. Any saline solution accomplishing the same purpose can of course be substituted for that of the sea salt. The simultaneous action on the mass treated results, it is claimed, in the perfect elimination of by-products, without any harmful effect on the solubility of the cellulose.

A general process for the preparation of hydrosulphites has been inaugurated by M. L. Descamps, which the Revue des Produits Chimiques says consists in causing the sudden action of zinc powder or any very fine and pure reducing powder on a concentrated solution of pure sulphurous acid, perfectly free from any other acid. The sudden elevation of the temperature to a point not too high is favorable for the instantaneousness of the reaction, which is a condition *sine qua non* of success. Another condition is also absolutely necessary; the reaction must be complete; no acid molecule must remain free, or decomposition will take place. The proportions to employ are 670 grammes of the powder per kilogramme of sulphurous acid in solution. The reducing powder should be slightly in excess, so that no particle of the acid may escape the reaction. The operation is economical, and the yield nearly theoretic. The product is stable and may be utilized as it is for the standard reactions, to convert it by precipitation of the base or by double decomposition, into another hydrosulphite.

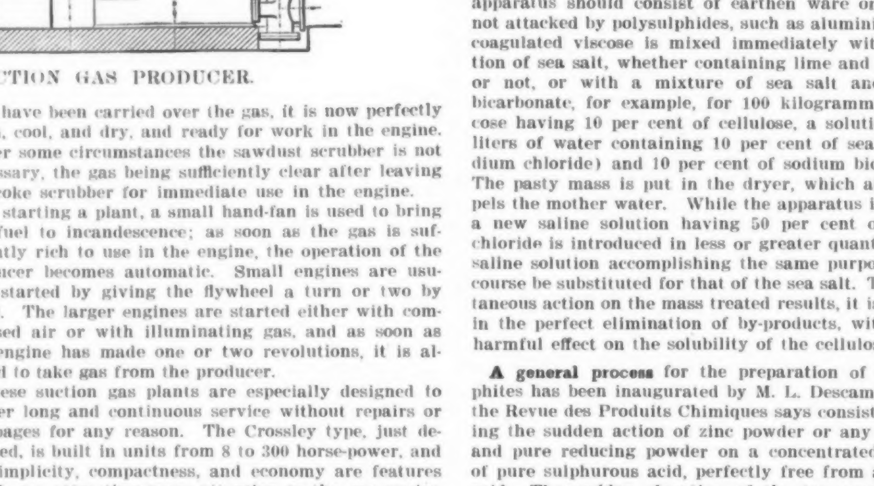


FIG. 1.—LONGITUDINAL SECTION OF LOOMIS-PETTIBONE PRODUCER.

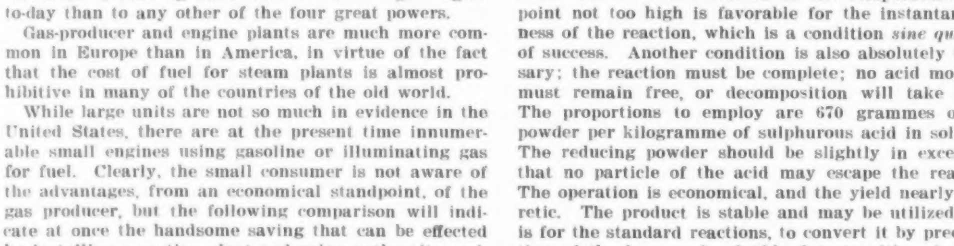


FIG. 2.—PLAN VIEW OF LOOMIS-PETTIBONE PRODUCER-GAS PLANT.

THE CULTIVATION OF MEDICINAL PLANTS.*

By E. M. Holmes, F.L.S., Curator of the Museums of the Pharmaceutical Society.

Judging from the numerous inquiries that have from time to time been transmitted to me on this subject, I am led to believe that there are many pharmacists interested in botany who would be glad to learn how many of the plants used in medicine could be cultivated in a small country garden, and the conditions under which they could be successfully grown. Such a collection would naturally be of interest to those who have apprentices preparing for examination. To such of our readers the results of experiments made during a series of years in this direction may therefore be of interest.

Spring and autumn, especially in the period of the early and later rains, which typically occur in April and July or August, are the seasons of the year when planting is most likely to succeed in the case of herbaceous plants, since the leaves do not then so readily lose moisture, and do not wither in a damp atmosphere, as they are liable to do if transplanted in dry weather, especially if the small roots are injured—as is usually the case when plants are dug up. For the same reason shrubs can be moved most successfully when their leaves have fallen in the autumn, as there is then no tax on the injured roots to supply moisture to the leaves, and there is also time for the new rootlets to form before the leaves appear in the spring.

In the following notes I propose first of all to deal with the medicinal plants of which a knowledge is required in the minor examination ("Syllabus," p. 5) and subsequently with plants of botanical interest which will serve as types of the natural orders of which a knowledge is required for the major examination ("Syllabus," p. 10).

PLANTS FOR RECOGNITION IN THE MINOR EXAMINATION.

Aconitum Napellus.—This plant can be moved at any time between October, when the leaves disappear, and the month of April. March is the best month, as the young leaves, which are then just starting, are very characteristic in their appearance, and this plant can then be easily distinguished by the green tint of the young leaves from the brownish leaves of *A. paniculatum*, and the more broadly lobed leaves of *A. variegatum*, two species which are often met with in gardens. Aconite is not very particular as to soil, but succeeds best where it is slightly damp or retentive; and, therefore, on a light soil does best on the shady side of the garden. The roots spread some distance, and starve less vigorous growers near it, so that one foot should be allowed on each side between it and other plants. The date of flowering of *A. napellus* is at the end of May. The plant takes two or three years to flower, if raised from seed, but the lower part of the stem, if earthed up, forms a root from each of the lowest leaf-buds. Buds are also produced on the roots, so that the plant is best propagated by these methods. The flowering tops are sometimes eaten by the caterpillar of a rare moth, *Plusia moneta*, which appears in April. The plant may be detected by the leaves being bent over toward the center, and by the black spots where the flower buds are eaten.

Papaver Rhœas.—There are several other species confounded with the *Papaver Rhœas*, inasmuch as they have red flowers and somewhat similar leaves. The true *Papaver Rhœas* has a globose fruit, and the hairs on the peduncle are spreading, but there is a variety, *strigosum*, which has adpressed hairs on the peduncles. The allied species with red flowers are: *Papaver hybridum*, L., which has a furrowed globose capsule with rigid hairs on it, and leaves with narrow segments; *P. argemone*, which has club-shaped capsules, furnished with rigid hairs; *P. dubium*, which has an oblong capsule without hairs, but with adpressed hairs on the peduncles, and of this species there are two varieties, viz.: (*a*) *Lamottei*, with short leaf lobes, and a capsule broadest at top; and (*b*) *Lecoqui*, with long leaf lobe, and the capsule broadest at about one-third from the apex. There is also occasionally found wild a plant having a purple patch at the base of each petal, the petals also being of a deeper red color; this is probably a hybrid with the garden species *P. umbrosum*, from which pollen has probably been carried by insects. The flowers of all these are probably collected for manufacturing syrupus Rhœados.

Papaver Rhœas does best in the sun, in a comparatively dry and light soil. The seeds should be sown where it is intended to grow, for the plant, like other poppies, does not readily recover after transplantation. The stem being weak and straggling, it is best to sow the seed sparingly in patches. To obtain fine flowers a little manure water is very useful, for although the red poppy likes a light soil, moisture and manure vastly improve its vigor.

Papaver somniferum.—This species grows wild in chalky cornfields in this country. The form so found, var. *hispidum*, has a lilac or pale mauve corolla, with a purplish spot at the base of the petals, and the peduncle has rigid spreading bristly hairs. But occasionally a glabrous form is met with, var. *glabrum*. The garden varieties, which are more or less hybridized and double-flowered, have usually grayish seeds (mawseed), whereas the white flowered variety (*album*) has pure white flowers and white seeds. This is best raised from poppy seeds found in the poppy capsules of commerce. Occasionally, however, these white seeds produce colored poppy flowers. In such case there is usually a reddish layer to be seen when the outer white coat of the seed is scraped. The white poppy, in order to grow freely, requires rich soil and plenty of moisture in dry weather. The poppy-heads, when fully formed, if collected for trade purposes, are generally bent in the middle of the peduncle, and allowed to hang downward to dry. To produce them of large size it is necessary to remove the succeeding flowers, or to feed the plant well.

Brassica alba and *Brassica nigra* grow readily from seed. The former prefers a calcareous soil; the latter a damp, rather rich soil.

Cochlearia Armoracia also prefers a soil not too dry, but does not readily flower if grown in the shade; it does best in a clayey soil. It does not fruit in this country.

Althæa officinalis grows naturally on the edge or sides of marsh ditches, where its roots are always in damp soil, and does well in any damp soil. But it is liable to be attacked by caterpillar of a moth, *Xanthorhoe cervinata*, which eats holes in the leaves, resting when not feeding in a short spiral position; it falls off directly the plant is touched, coiling itself on the ground into a ring like the unripe fruit of the mallow.

Ruta graveolens flourishes best where its roots are protected by rockery or in stiff calcareous clay, and where not exposed to the east or northerly winds. If grown in shade it is apt to grow too luxuriantly and succulent, and consequently suffers more in winter than if grown in the sun.

Cytisus scoparius grows best in poor, sandy soil. In rich soil it grows very large, and a series of young plants should be kept so as to cut down the old plant when it becomes large and unsightly.

Rosa canina is, of course, rarely grown, but like all roses prefers a rich, loamy soil, and if much space cannot be spared for it, should be grown near a fence and pruned, so as to make only lateral growths, the weaker shoots being cut out and the old ones cut down in the autumn when large, strong shoots have arisen from the base during the summer. These may be pruned in March, all the shoots that have produced leaves at the end of that month being cut away so far as the leaf-buds have opened.

Prunus Lauro-cerasus.—Of this plant there are a number of varieties, var. *Caucasica* being one of the hardiest, and var. *Colchica* one of the least hardy; var. *Schipkaensis* is a dwarf slow-growing variety, but does not show the glands at the back of the leaves so well as the larger varieties, but in another small-leaved but taller plant, var. *camelliæfolia*, the glands are easily seen. In var. *rotundifolia* the leaves are rounded at the apex, and var. *latifolia* has the largest leaves. Like many rosaceous shrubs and trees some of the branches are apt to die off. This can be prevented to a great extent by keeping the plant clipped in spring before the new leaves appear, and in autumn at the end of September before the frost begins. The shrub flowers more readily if growing where its roots are restricted, and in a sunny aspect, and if the branches are thinned out so as to admit light and air between them. The fruit, like black cherries (whence its name of cherry-laurel), is rarely produced.

Bryonia dioica.—This plant grows only too rapidly in a sandy soil. It is easily raised from seed and should be planted near a fence, as it grows with great rapidity and starves the roots of herbaceous plants near it and climbs for a great distance. The plant being diœcious, a male and female plant are required to illustrate its character. The species used by homœopaths, viz., *Bryonia alba*, is monœcious and has black berries, but it does not grow so readily as the *B. dioica* in this country, in my experience. I have not been able to induce it to fruit. *Conium maculatum* is not particular as to soil. It is biennial and does not, therefore, flower in the first year. In rich soil in the shade it will grow six or eight feet high in the second year, when it flowers.

* Pharmaceutical Journal.

DAYTIME OBSERVATIONS ON THE NORTH STAR.

To find the star when the sun is above the horizon, certain preliminary observations must be attended to, about the middle of September, as soon after sunset as the star can be seen by the naked eye, being at this time very near its eastern elongation. First, the observer must be provided with a good engineer's transit, and he must see that the eye-glass is accurately focused on the cross-wire in the telescope tube, for his own eye.

Having the instrument firmly planted on solid ground and the star brought into the field of view, the object glass must then be accurately focused on the star, and a cut made on the telescope tube, at the end of the slide, as a slight variation in the focus will put the star out of sight in the daylight. The horizontal cross-wire being set on the star, the angle of elevation can be read on the vertical circle, about 42 deg. 30 min. in this latitude. A light may be needed to read these figures. A hub must be set in the ground accurately under the center of the transit and a stake and nail set some distance in front. The cross-wire in the telescope can be seen some little time after sunset.

These directions having been carefully attended to, the daytime experiment may be commenced about the middle of October. Setting instrument over the hub about 5 o'clock P. M., and taking a line from the nail set in the stake, adjusting the focus of the object glass on the mark at the end of the slide, and elevating the telescope to the degree and minute on the vertical circle, the star should be seen very near the vertical wire, but may be either above or below the horizontal wire. Setting the vertical wire on the star the observer must note very carefully whether the star appears to remain stationary, or leaves the star on the west side of the wire. If in a short time it leaves on the west side, the work has been too late and must be commenced earlier the next afternoon, when the star will be found leaving the wire on the east side. When it reaches its eastern elongation, it will remain on the wire for nearly half an hour, 15 minutes before and 15 minutes after elongation, giving ample time to project down to the ground and fix permanent marks.

To fix the true meridian from the eastern elongation, the azimuth angle, taken from some work on surveying for the year, and latitude must be turned off to the west, and this line marked for the true meridian. If the observer desires to test his work, twelve hours after taking the eastern elongation, he may get up in the morning and take the western elongation; fixing a point and bisecting the distance between the two elongations, the true meridian can be found without reference to the azimuth angle taken from the book.

About 5 o'clock P. M., October 23, at Salem, Mass., on the Essex County meridian, the writer observed an eastern elongation and fixed a point on a nearby fence, and about the same hour the next morning took the western elongation. Deducing the true meridian from these observations, the Salem true meridian was found to be out about 12 inches in the whole length of the line, 400 feet. Some years previous to this the other Essex County true meridian at Lawrence was found to be out about 3 inches in 400 feet.

These county meridians were authorized by an act of the Massachusetts Legislature, passed at the 1870 session. The work was to be executed under the direction of the county commissioners for each county. The line was to be fixed on the ground by three stone monuments, one at each end of a line 400 feet long, and one in the middle, and the true meridian was to be ascertained by astronomical observation; but instead of that, the parties who had the job for Essex County undertook to fix the true meridian by daytime observations on the sun at noon, hence the foregoing result.

When the sun reaches the meridian the motion is very rapid, as it remains in the meridian only an instant, and an observer must work very quickly to catch it; then he must have perfectly accurate time. Consequently, the North Star observations are much more convenient and accurate than any sun observation can be.

The law of Massachusetts authorizing these true meridians requires all land surveyors to test the variation of their compass needles at least once every year, the variation for the day and hour to be noted and recorded in a book kept for the purpose by one of the county officials. Neglect subjects him to a fine of $10, but I doubt if any fine has been collected in this county.

If the law had been enacted one hundred years ago and enforced, it would have been of more or less importance in retracing lines fixed by course and distance in old deeds, but at the present time very few lines are fixed by the courses indicated by the magnetic needle, especially if anywhere in the vicinity of electric wires. Several years ago the writer had occasion to take his transit some three miles in an electric car. On reaching his work and setting up the instrument he found, to his astonishment, that his compass needle was dead. On examination it was found to be completely demagnetized. Ever since that experience he has been very careful to see that the compass needle was unclamped and swinging whenever taking the transit on an electric car.

The writer commenced observing the declination of the magnetic needle from a true meridian established at Haverhill, Mass., about the middle of August, 1859, and has continued these observations at least once a year for every year since. The variation of the needle at that time at Haverhill was 11 deg. 45 min. west. In October, 1903, it was 13 deg. 30 min. west, but these changes have been at anything but a uniform rate. Not the slightest change could be detected for three years, after 1859, when all at once, apparently, it read 12 deg. There has been no uniform motion since, and consequently no scheme for interpolating magnetic courses would be of any value; but here, at the present time, it is customary to allow five minutes per year for the declination, thus helping the surveyor sometimes to guess where some mark ought to be found.—N. Spofford in Engineering Record.

Manufacture of Nitric Acid.—The Revue de Chimie Industrielle describes in detail the new Gladbeck process for the manufacture of nitric acid by means of atmospheric air. It is based on the known fact that air heated to a temperature of at least 1,200 deg. C. is partially converted into nitrogen bioxide. The proportion of the bioxide increases with the temperature, according to the law of dissociation (equation of the equivalents of reaction). For example, at 1,700 deg. C. the percentage in bioxide would be, according to recent analyses, about 3 per cent. To effect the separation between the air and the bioxide of nitrogen formed, to avoid the difficulty experienced by re-conversion in the opposite direction attending progressive cooling of the air raised to such high temperatures, is the result sought for. The air or any desired mixture of oxygen and nitric oxide, after being thus heated, is subject to cooling so rapid that the inverse reaction is rendered impossible. The lowering of the temperature may be secured by means of chilled metallic or other surfaces, or by means of cold indifferent liquids or gases, or by any other means that will cause a rapidity of cooling greater than that of the decomposition of the bioxide of nitrogen formed. Any apparatus that will allow of raising the temperature to the necessary point, and then of its sudden cooling, is available.

THE N-RAYS OF M. BLONDLOT.*

By C. G. ABBOT.

DISCOVERY.

IN the early part of the year 1903 M. Blondlot, professor of physics at the University of Nancy, was carrying on some studies of the X-rays to discover if these could be polarized. He found that a convenient method of recognizing the presence and possible polarization of these rays consisted in the employment of a small electric sparking device. Two sharpened wires, communicating inductively with the terminals of a Ruhmkorff coil, were so nearly approached that feeble sparks continually passed between them, and upon bringing this sparking device near a source of X-rays the luminosity of the sparks was found to increase. M. Blondlot at first thought he detected by his experiments a considerable degree of polarization in the X-rays, but a little later he decided that it was not the X-rays themselves which gave the appearance of polarization, but a new kind of rays heretofore unrecognized. In his first experiments with these rays their source was a Crookes tube provided with a thin covering of aluminium to cut off the light. The rays which traversed the aluminium then passed through a rectangular opening in a sheet of lead and fell upon the little sparking device already mentioned. It was found that only when the line of sparks flew in a certain direction, as compared with the slit in the leaden sheet, could the maximum brightness be observed, and this direction for maximum brightness was altered when a substance which rotates the plane of polarization of light was introduced.

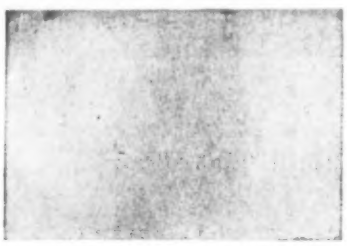
The experiments on polarization suggested to M. Blondlot the possibility that the new rays might also be refracted. He tested this by interposing a quartz prism, and found that in fact the rays were now diverted from a straight line, so that he was obliged to carry the sparking device to one side in order to reach a point of increased luminosity. By means of a quartz lens the fact of the refraction of the rays was further verified, and following this it was found that the rays could be reflected regularly and diffusely, just as is the case with ordinary light. As polarization, refraction, and reflection are not qualities of X-rays, but are essentially qualities of ordinary light, M. Blondlot drew the conclusion that he was now dealing with radiation propagated by waves in the ether in essentially the same manner as ordinary light. This new type of rays he found to be transmitted by wood, paper, aluminium, and many other metals, but to produce no direct effect upon the eye, the photographic plate, or a phosphorescent screen, and he was at first unable to recognize them excepting by means of the little sparking device.

The experiments with refraction in prisms and lenses had indicated that the index of refraction of these rays in quartz was very high and indeed exceeding 2. Prof. Rubens had not long before discovered rays of great wave length for which the index of refraction in quartz was about 2.18. This similarity of refractive index led M. Blondlot at first to think that perhaps he was now dealing with a type of radiation belonging to the extreme infra-red, and as Rubens had employed a Welsbach lamp as a source of the radiations he had measured, M. Blondlot sought to determine if these new rays were also emitted by this source. Shielding the lamp which he employed by an iron covering having a small aluminium window, he was able to detect the presence of the rays in question in its radiation by the aid of the small sparking device. When the quartz lens was used to form an image of the source, the rays appeared not to be homogeneous, but to contain at least four different varieties whose indices of refraction were, respectively, 2.94, 2.62, 2.44, and 2.29. With the exception of lead, rock salt, platinum, and water, the rays were found to be transmissible by moderate thicknesses of many different substances, including tin foil, copper, aluminium, steel, silver, gold, paraffin, black rubber, and others.

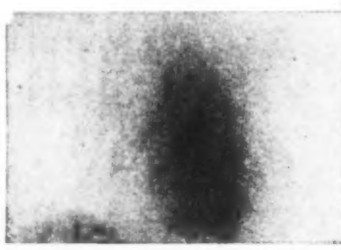
SOURCES OF THE RAYS AND METHODS EMPLOYED IN THEIR RECOGNITION.

M. Blondlot now gave a name to these rays, calling them N-rays, after the city of Nancy, in which he lives. He claims to detect their presence in the emission of luminous gas flames, as well as in the sources already mentioned, but he failed to find them in the emission of a Bunsen burner. The Nernst lamp is spoken of as a specially intense source of them.

Other methods of recognizing the rays were now introduced, for M. Blondlot was led to inquire whether the sparking device acted as a sign of their presence by virtue of its electrical properties or by virtue merely of its emission of light. Accordingly he used a small blue flame instead of the device, and found with it also an increased luminosity when placing it in the focus of the rays. A little later he found that phosphorescent substances, though not excited directly by the rays, yet if first made feebly luminous by ordinary light were raised to a higher luminosity when exposed to the N-rays. In later experiments it appeared that a surface feebly illuminated by reflected light became brighter under the influence of N-rays. Still more remarkable, he found that if the N-rays fell only on the eye of the observer, and not on the object observed, the latter was nevertheless made to appear more luminous, though the N-rays themselves produce no sensation of light. Photography failed as a direct method of observing the rays, but he used it indirectly to note the increased luminosity of the spark, the blue flame, or the phosphorescent surface which was employed to recognize the presence of the rays. The accompanying figure, taken from the Comptes Rendus of February 22, 1904, shows an example of this indirect photographic method. Experiments with the most sensitive apparatus failed to record any sensible heating produced by the N-rays.



Photograph of an electric spark under the action of N rays from a Crookes tube, the axis of the spark being perpendicular to the axis of the tube.



Photograph of an electric spark under the action of N rays from a Crookes tube, with the axis of the spark parallel with that of the tube.

M. Blondlot makes the following general remark concerning the observation of the N-rays:

"The ability to recognize slight variations of luminous intensity varies very much between different persons. Some see at the first glance, without any difficulty, the augmentation which the N-rays produce in the brightness of a small luminous source, while to others these changes are very near the limit which they can distinguish, and it is only after some experience that they are able to be sure of having observed the phenomenon. The feebleness of these effects and the delicacy of the observation ought not, however, to arrest our study of these heretofore unknown radiations. I have found recently that the Welsbach burner may be advantageously replaced as a source by the Nernst lamp with no glass covering, for this latter gives forth the N-rays with greater intensity, and thus with a 200-watt lamp, for example, the phenomena are so marked that they may be easily observed."

N-RAYS FROM THE SUN.

The following simple experiment is given by the discoverer to show the existence of N-rays in the solar beam:

"A completely darkened chamber is furnished with a window exposed directly to the sun's rays, and this window is closed by an oak shutter at least half an inch thick, so that no ordinary light can possibly penetrate into the room. Behind this shutter, at about a meter distance, for example, is placed a small glass tube containing a phosphorescent substance—sulphide of calcium, for example—which has previously been exposed to light and become feebly luminescent. If, now, in the beam of the sun, which we suppose to pass through the wooden shutter and fall upon the phosphorescent tube, we interpose a screen of lead, or even simply the hand of the observer, though at considerable distance from the tube, the brightness of the phosphorescence is seen to diminish, and upon removing the obstacle the brightness again increases. The only precaution which it is necessary to take is to employ a tube only slightly phosphorescent, but it is advantageous to place behind it a black paper, so that the interposition of the screen produces no change whatever in the background against which one sees the tube. The variations of brightness are most easy to observe near the boundaries of the luminous spot formed upon the black background by the phosphorescent body, and when the N-rays are intercepted these contours lose their sharpness and regain it when the screen is removed. Sometimes the variations of brightness are not instantly recognized. Interposition in the path of the beam of several sheets of aluminium, of cardboard, and even of a board of oak more than an inch thick, does not prevent the effect, so that all possibility of the action of any ordinary radiation is of course excluded. A thin sheet of water, however, entirely arrests the rays, and thin clouds passing before the sun considerably diminish their action."

WAVE LENGTH OF THE RAYS IN QUESTION.

M. Blondlot, as we have seen, was at first inclined to think that his rays belonged in the extreme infrared spectrum, but more recently he has described measures of their wave length by means of the diffraction grating which lead him to the opposite conclusion. He employed a spectroscope with aluminium prism to separate the several different species of N-rays emitted by a Nernst lamp, and then estimated their wave length by means of several different diffraction gratings having respectively, 50, 100, and 200 lines to the millimeter. The following table contains the results of his measures:

Indices of refraction in aluminium.	Wave lengths.			
	Grating employed.			Probable values deduced from the preceding.
	Rulings 0.02 mm.	Rulings 0.01 mm.	Rulings 0.5 mm.	
	μ	μ		μ
1.04	0.00813	0.00795	0.00830	0.00815
1.19	.00930	.01020	.01060	.00980
1.40	.01170	....	....	.01170
1.68	.01460	....	....	.01460
1.85	.01760	.01710	.01840	.01760

Thus it appears that the N-rays belong far beyond the previously studied ultra-violet, and have a wave length only one-tenth that of the rays with which Dr. Schumann has been working with his vacuum spectrograph. It is somewhat extraordinary that the N-rays should so readily traverse thicknesses of the air and other substances which would entirely arrest the ultraviolet rays examined by Dr. Schumann, but, as is the case in other regions of the spectrum, it may be that the air has here special bands of great absorption, in one of which Dr. Schumann's rays lie, and that beyond this region there are other parts of the spectrum where the air is again transparent. Another curious thing about the measures just given is that the aluminium prism appears to be anomalously refracting; in other words, its indices of refraction increase rather than decrease with increasing wave length of the rays. M. Blondlot suggests that the augmentation of brilliancy observed in a small luminous source under the action of the N-rays may be attributed to a transformation of these radiations into luminous ones in conformity to the law of Stokes.

STORING UP OF THE N-RAYS.

M. Blondlot finds that many substances are able to store up the N-rays and emit them for some time after having been subjected to the influence of a source. This property, it will be seen, is similar to the phe-

Photograph of a spark without N rays acting upon it.

Photograph of a spark with N rays produced by acting upon it.

Photograph of a spark without N rays acting upon it.

Photograph of a spark with N rays produced by a Nernst lamp.

PHOTOGRAPHS OF INCREASED LUMINOSITY PRODUCED BY N-RAYS.

* Reprinted from Smithsonian Institution's Annual Report.

nomenon of phosphorescence which is observed with ordinary light. Among the substances which appear to store up the N-rays are quartz, Iceland spar, fluorspar, glass, and many others. Aluminium, wood, paper, and paraffin, on the other hand, do not appear to possess this property of storing up N-rays to any very appreciable extent. The phenomenon is so general that a large portion of the bodies upon which the sun's rays fall are said by M. Blondlot to become saturated with the rays and to give them out undiminished in some cases as long as four days after they have been removed from the influence of the sun.

N-RAYS PRODUCED BY MECHANICAL PROCESSES.

It appeared that compression and other distortions of metals, wood, glass, rubber, etc., caused these substances to emit N-rays while under such mechanical constraint. Crystalline substances, tempered steel, and some other bodies possessing special internal structure, are stated to be spontaneous and permanent sources of N-rays. As an illustration of the permanence with which this property remains associated with such substances, M. Blondlot mentions that a sword found in an ancient sepulcher dating from the Merovingian epoch, was found to give out the N-rays strongly. It thus appears that the emission of the N-rays by tempered blades of steel may continue for centuries without becoming enfeebled, and as regards continuous emission, therefore, the N-rays may be compared with the radiation of uranium, radium, polonium, and other sources of Becquerel rays, although, of course, in other respects the two kinds of radiations are entirely different.

EMISSION OF N-RAYS BY THE HUMAN BODY.

M. Charpentier, while repeating in his laboratory many of the experiments of M. Blondlot on the production and observation of N-rays, noted that the luminosity of phosphorescent substances used to detect the presence of the rays appeared to increase when the observer approached these phosphorescent substances. Continuing the studies which this observation led him to pursue, he found that the increase of brightness was most considerable in the vicinity of a muscle, and was greatest when the muscle was strongly contracted. Nerves and nervous centers were afterward found to produce similar effects, and he was even able to follow in this manner the course of certain nerves beneath the skin. These experiments suggested to him that the human body, at least some portions of it, might be emitting N-rays, and he found that the emissions observed passed readily through aluminium, paper, and other substances classed as transparent to the N-rays, and that they were arrested by lead and moistened paper which had been used by M. Blondlot as screens. The rays were further found to be reflected and refracted, and could be brought to a focus by the aid of convex lenses, and appeared to have about the same indices of refraction as the N-rays themselves. It seemed possible, however, that the human body acted merely as a reservoir, storing up the rays like some other substances in which such action had been observed by M. Blondlot, but M. Charpentier states that after continuing nine hours in complete darkness the rays were still emitted by the body, though perhaps a greater sensitiveness of the eye under these conditions may have made it more easy to recognize them. However, M. Charpentier is of the opinion that the human body certainly emits N-rays, and especially in those parts of it which are in active use.

From later experiments it was concluded that the lower animals, such as the monkey and others, are active sources of the N-rays, and that here, as in man, the principal seat of the emission is in the muscles and nerves. It was not alone the warm-blooded animals which appeared to give rise to emission, but also the cold-blooded—frogs and others. As in the case of metals and other substances experimented upon by M. Blondlot, mechanical constraint, such as the compression of nerves and muscles, greatly augmented the luminous effects. In order to localize the observations in a convenient manner, M. Charpentier uses a narrow lead tube from two to four inches in length, of which one end is placed in contact with the body to be examined and the other contains the phosphorescent substance used as the indicator. He states that he can thus trace out the regions of the brain which are active in special functions, such as the "center of Broca," reputed to be the seat of articulate language.

It appears from Charpentier's later experiments that the physiological emissions are not exclusively composed of N-rays, but include other kinds of radiation differing in some degree in their properties from those which have been found associated with the N-rays.

TRANSMISSION OF THE N-RAYS ALONG WIRES.

In the course of M. Charpentier's experiments he found that the rays emitted by the human body are capable of being transmitted not only in the air, but along wires of metal, such as copper or aluminium. This extraordinary discovery has been explained by M. Bichat, who observes that this method of transmission may be compared to the repeated reflections of ordinary light within a long glass tube. His experiments indicated first of all that the wire itself was certainly the conductor of the rays, and not the medium in which it was placed, for upon immersing the wire in water the conductivity remained undiminished. It was necessary, moreover, that the wire should be of good transmitting material, for leaden wires are said to transmit nothing. The wire must not be bent at a sharp angle, nor should it be rough at any point, for in these cases the internal reflections along its boundary cannot be propagated.

N_1-RAYS.

Some very recent experiments of M. Blondlot led him to think that, whereas the N-rays augment the luminosity of certain sources of light, there is another kind of rays associated with them which diminishes instead of augments the luminosity, and he has investigated these rays among those emitted by a Nernst lamp. These so-called N_1-rays he finds to be reflected and refracted similarly to the N-rays, but to lie alternately with them in wave length, so that, for example, he states that a group of N_1-rays exists of wave length $.003\ \mu$, a group of N-rays at $0.0048\ \mu$, another group of N_1-rays at $0.0056\ \mu$, N-rays at $0.0067\ \mu$, and N_1-rays at $0.0074\ \mu$. All of these new groups, both N and N_1, are of smaller wave length than those included in the table already given.

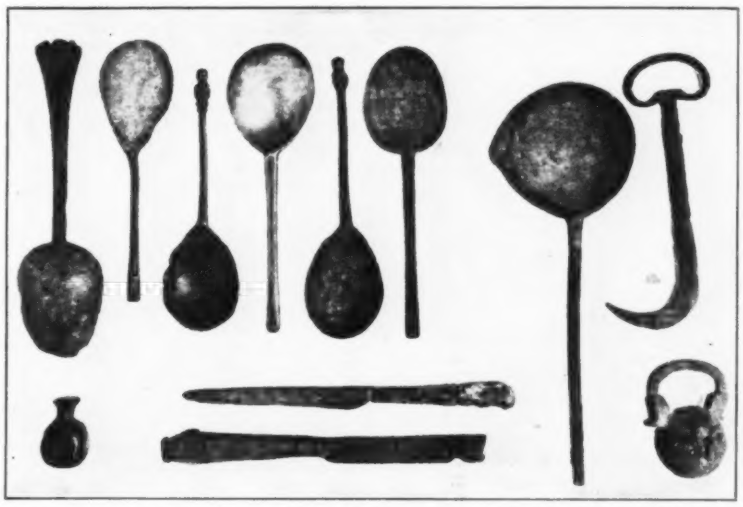
Certain sources appear to emit exclusively, or at least principally, the N_1-rays, such as copper, silver, and platinum. The N_1-rays may be stored up, he states, like the N-rays.

CONCLUSION.

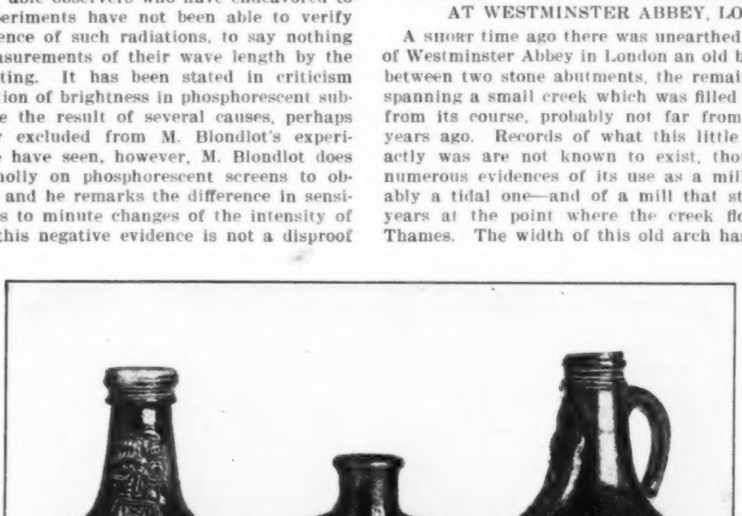
To sum up these newly reported discoveries and experiments, it appears that several other men of scientific standing and attainments have repeated and verified M. Blondlot's discoveries of the N and N_1-rays and those of M. Charpentier on the rays emitted by living bodies. The observations appear, however, to be difficult, and many able observers who have endeavored to repeat the experiments have not been able to verify even the existence of such radiations, to say nothing of making measurements of their wave length by the diffraction grating. It has been stated in criticism that augmentation of brightness in phosphorescent substances may be the result of several causes, perhaps not sufficiently excluded from M. Blondlot's experiments. As we have seen, however, M. Blondlot does not depend wholly on phosphorescent screens to observe his rays, and he remarks the difference in sensitiveness of eyes to minute changes of the intensity of light, so that this negative evidence is not a disproof of the existence of the rays in question. On the other hand, the positive photographic evidence afforded in the illustrations given by M. Blondlot, which does not at all depend on phosphorescence, but only on the brightness of the little sparking device, seems to outweigh indications depending merely on sight alone.

In connection with M. Charpentier's physiological rays, it may be recalled by the reader that a half century ago there was great interest aroused, both in scientific and popular circles, by the accounts of the so-called "odic force" of Reichenbach. This was said to be manifested as a luminous aureole which appeared to some observers to surround certain persons. For some time there was a controversy between those who claimed they could see it and those who certainly could not see it, but at length the discussion disappeared from the journals, and the general impression has been that no such thing really existed.

Some persons have thought that these new discoveries of M. Charpentier and others may in a certain sense revive the old idea of such an aureole thrown out by living people, but the methods of observing the new rays are evidently wholly different. The physiological rays now being discussed cannot be seen by the naked eye, nor do they affect the photographic plate or any other of the ordinary means of observing light, and they are only to be distinguished indirectly by the augmentation of brightness which they produce in feebly luminous objects. Accordingly, however interesting it may be if we know that the living body actually is surrounded by special radiations which it emits in addition to those rays of great wave length which we have long known are emitted by every body, living or dead, above the temperature of absolute zero, still so long as our eyes cannot see them they can hardly be supposed to belong in the category of the aureole of Reichenbach. It is to be hoped that they will not, like this asserted aureole, fall into scientific oblivion.



A NUMBER OF CURIOUS RELICS FOUND WHILE EXCAVATING IN THE GARDEN OF WESTMINSTER ABBEY.



BROWN "GRAYBEARD" JUGS AND A GREEN GLAZED EARTHENWARE BOTTLE FOUND AT THE SAME TIME.

DISCOVERIES MADE IN RECENT EXCAVATIONS AT WESTMINSTER ABBEY, LONDON.

A SHORT time ago there was unearthed in the garden of Westminster Abbey in London an old brickwork arch between two stone abutments, the remains of a bridge spanning a small creek which was filled in or diverted from its course, probably not far from two hundred years ago. Records of what this little waterway exactly was are not known to exist, though there are numerous evidences of its use as a millstream—probably a tidal one—and of a mill that stood for many years at the point where the creek flowed into the Thames. The width of this old arch has not yet been determined, so that it is impossible to say at this time whether it is a part of a street bridge or whether, after the disuse of the mill and millstream, the latter was vaulted over to gain ground for building or other purposes. If the arch were found to extend backward from the present point of excavation, it would lead to this supposition.

The photographs are of a few of the many curious relics of years ago, which were discovered during the excavation here and under some old houses in the immediate vicinity. There is a large number of these interesting objects, most of them being of the seventeenth century. They include pottery, spoons, knives, and tobacco pipes. But the most valuable find is a writhed Purbeck marble shaft, which is clearly the

upper part of the northeastern angle shaft of the Confessor's shrine in the Abbey. It exactly fits that position, and has now been restored to its place.

The first photograph shows a half dozen spoons of pewter, brass, or brass plated with tin. The second from the left, a small slip-ended pewter one, is probably the oldest, and is believed to be of the sixteenth century. The other objects in this group are a brass straining ladle, a pot-lifter of iron, two knives, one with a blue-stained wooden handle inserted in an iron ferrule and the other with an engraved haft of bone, a small bail-shaped padlock, and a small glass bottle.

The second illustration shows two brown "Graybeard" jugs and a green-glazed earthenware bottle. One of the most interesting of all these finds was the jug on the left of the second photograph. When found, it was stoppered with a cork, and when opened and its contents washed, these were found to be as follows: A small piece of cloth or serge, formerly red, cut carefully and neatly into a heart shape, and stuck full of round-headed brass pins, each pin bent. A small quantity of hair, ostensibly human, and some finger-nail parings. There can be little doubt that this was intended to be a malevolent charm, the intended victim of which was probably a woman, and the evil wisher doubtless also. The jug and its contents were probably buried in the seventeenth century.—Architectural Review.

THE PALACE AT NIPPUR NOT MYCENAEAN BUT HELLENISTIC.

In Scientific American Supplements 1528 and 1529, Mr. Clarence S. Fisher publishes an article entitled "The Mycenaean Palace at Nippur." The building in question was discovered in the University of Pennsylvania excavations of 1889-1894, and published by Dr. John P. Peters in the American Journal of Archaeology [First Series], vol. x., 1895, pp. 439 ff., and in his Nippur, Second Campaign, 1897, chapter VI. Dr. Peters for a long time supposed this building to be of late date—"not earlier in any event than the Persian period and probably influenced in the use of columns by Greek art." The discovery of some Cassite tablets outside the palace has, however, changed his opinion and has led him, finally, to assign the palace "somewhere between 1450 and 1250 B. C." A very different opinion is held by Prof. Hilprecht (Explorations in Bible Lands, 1903, p. 337), who assigns it "without hesitation to the Seleucido-Parthian period, about 250 B. C."

When we consider how little is known of Cassite architecture on the one hand or of Parthian on the other, and how scanty are the data furnished by the earlier excavations, it is not strange that two Oriental scholars, without literary or epigraphic evidence, should differ in their judgment of architecture by a thousand years.

But now that the excavations have not only enlarged our knowledge of the plan of the building but have furnished us with architectural details of well-defined form and character, we are in a position to judge more securely of the period to which the palace should be assigned. The recent excavations have brought to light some objects apparently Mycenaean, found like the Cassite tablets outside of the palace and on the same level. These appear to have suggested to Mr. Fisher that the palace also is Mycenaean. This hypothesis gained weight with him as he discovered Parthian burials and late Greek objects in the strata above the palace, and he then attempts to prove that the palace is Mycenaean in plan, and that the architectural details must be Mycenaean also.

Into the argument based upon strata we cannot enter here. Inferences based upon the levels where objects are found have proved valueless in so many cases that we needs must have evidence of indubitable superposition, as, for example, when walls are built upon old foundations, before we can feel assured of chronological succession.

The evidence provided by the plan and details of the building can be more readily discussed by those who have not visited the site. Mr. Fisher compares the plan with that of Tiryns, pointing out a number of resemblances. Most important of these is the setting of the *megaron* with its *prodomos* behind a peristyle court. This would indeed seem striking if such a plan were specifically Mycenaean. But Greek houses in general followed essentially this disposition to the end of the Hellenistic period. Even the houses of Pompeii differ but little in type. The plan of the palace at Nippur betrays its late origin in the fully developed square peristyle with compound piers at the angles, and in the elliptical columns of the *prothyron*. In all the Mycenaean sites thus far excavated, so far as I am aware, no examples have been found of compound piers or of elliptical columns. But in the Hellenistic Agora at Priene the corner piers are provided with engaged columns to adapt them to the rectangular peristyle, and in the Hellenistic Agora at Pergamon elliptical shafts are still standing. The later history of these Hellenistic inventions may be traced in Oriental as well as in Occidental architecture.

More startling is it to find Mr. Fisher describing the two pedestals at the entrance of the palace as Mycenaean. These pedestals have convex faces of graceful curves, impossible in Mycenaean times, and difficult to parallel in Greek work of the best period. Moreover, their general form and their base and cap moldings recall well-established Hellenistic types. Here a Lesbian kyma surmounts an ovolo, and we might expect to find a painted leaf-and-dart above the egg-and-dart, as Hellenistic sculptors were wont to carve them upon similarly formed and related moldings. Mycenaean architects constructed buildings of crude brick and of wood and made little use of stone except for city walls and for foundations. Moldings like these have their origin in the decoration of fine stone and marble buildings, and are entirely lacking in Mycenaean architecture.

The columns at Nippur also betray by their forms a non-Mycenaean character. The shafts are described as cylindrical for the lower third, from which point they taper toward the top. This type of shaft may be found in the Hellenistic temple of Apollo at Didyma, near Miletus, and in later examples at Pompeii and elsewhere. It was probably adopted because this form suggested the traditional entasis and, at the same time, avoided the difficulties involved in calculating and executing it. The Mycenaean shaft had no such past history and presents no such form. If we may judge of free-standing columns by relief representations, the Mycenaean shaft tapered uniformly and from the top downward.

The capital of the column with its low and slightly projecting echinus has little or no resemblance to the Mycenaean torus capital, and is equally far removed from the early Doric overhanging echinus. Nor has it the strong echinus of the classic Doric capital. To find analogous forms we must descend to the Hellenistic period, when, as in the Agora at Priene, the echinus has often a curved profile, not widely overhanging, nor strong and massive, but crowning the shaft like the kymation of the Ionic capital.

We are told that above the palace Dr. Hilprecht has recognized Parthian graves ranging in date from 250 B. C. to 226 A. D. It follows that he must now assign the palace to a date earlier than the earliest of these Parthian graves. But that the palace is, as Mr. Fisher declares, one thousand years earlier than these graves, is refuted by the distinctly Hellenistic forms afforded by the architectural details.

Princeton, February 9, 1905. Allan Marquand.

HEAT TRANSMISSION: WHAT IT IS AND HOW IT IS ATTAINED.*

The three recognized methods of transmission of heat are *convection*, *conduction*, and *radiation*. This does not mean that we have three different kinds of heat, that one kind of heat is lost by conduction, one by convection, and one by radiation. It means three processes are operative.

The first method, convection, we may briefly define as the transmission of heat by the movement of matter itself. You have illustrations of this in the ocean currents and trade winds which are so important in tempering the earth's climate. It depends entirely on the fact that matter when heated expands and becomes less dense. Therefore, a heated portion of matter surrounded by cooler matter will be displaced by the cooler matter as a light object is displaced by water. So we have heated matter rising when surrounded by cooler matter. We have one exception to this in water at 4 deg. C. As an illustration of this showing the maximum density of water we have twelve thermometers of equal bulbs containing equal weights of water. One bulb is placed at zero and the others in successive degrees to twelve. At four degrees we have the maximum density or the liquid occupying the least volume. Below that point to zero, water expands. Above that point, as high as we can go, water expands; hence we see that in the case of water the process of convection will cause a current of warmer water to rise until we get to four degrees, and then the reverse process will take place. Below four degrees, as the water becomes cool, the warmer layers sink to the bottom. Now, that has a very important influence, as we shall see presently, in ice formation in lakes and quiet water.

The next process of heat transmission is conduction. By conduction we mean the transmission of heat from point to point in the body. Heat is a form of energy; it is a measure of the vibration of the molecules of a body. When the molecules at one point become warm or vibrate more energetically these vibrations are conveyed to neighboring molecules.

Conduction only affects the ice problem in so far as it causes a thickening of the sheets of ice over a river or lake. We can measure the conduction and we know it in definite units for ice and for water, and in any problem in which conduction enters we can calculate with a fair degree of exactness the rate at which ice will form; otherwise, conduction plays a very little part in river ice formation.

The next process is that of radiation, or the transmission of heat by ether waves. All bodies radiate energy by ether waves which travel out in all directions in straight lines with a velocity of 187,000 miles a second. They are, in fact, merely a continuation of the ether waves which are capable of affecting the optic nerve, and which we call light, and we know some of these light waves possess heating qualities.

These waves extend for a long distance beyond the visible spectrum and they are being investigated and the limit pushed further and further down. All light waves travel with the same velocity and hence the length of the waves and the number of vibrations of the waves must vary correspondingly. The longer the wave the slower the vibration. Now we know that this is one fact that distinguishes the heat waves from the light waves. We can extend down for a long distance, almost to connect with the electrical waves which we are able to produce, but we have not yet bridged over a long gap which exists. When we come to examine the whole spectrum of ether waves we pass up from the electrical into shorter waves which possess heating qualities. We pass on to shorter waves still, light; we pass beyond these into waves which are still shorter, ultra-violet; we pass on further, and we come where—perhaps to the X-ray, for the latest ideas in regard to these X-rays are that they are very short waves of ether.

We can prove in a wonderful way that the heat waves are similar to light in that they may be reflected, refracted, and polarized.

Now the problem of heat transmission by radiation is the most difficult. We know the least about it. A great deal has been done recently in unearthing the laws of radiation from black bodies. And we have in applying our knowledge of radiation to problems, first of all to make a calculation of what it would be if the object were a black body. Then we must make estimates. Every kind of surface depending on its roughness and its temperature will send out or absorb different kinds of waves. In general, the higher the temperature of the body the more of the light waves or shorter waves are sent out and the fewer the longer waves. The lower the temperature the fewer of the shorter waves will be sent out and the more of the long. Finally we get bodies which are not luminous at all, and then if we take bodies still colder we find that they emit longer and longer rays the colder they become. Now the difficulty in applying the laws of radiation to practical engineering problems is that we do not know enough about surface conditions or radiation from cold bodies.

Bodies differ a great deal in their power of absorbing rays. Some bodies transmit heat waves; some do not. We have, for example, in colored glasses, very beautiful illustrations of how some bodies transmit light waves and some do not. Some of the rays are absorbed and some can go through. Tyndall has shown us that for heat rays water and ice are very opaque, and he has pointed out that of the longer rays which are emitted from an object heated one hundred degrees above its surroundings, the surroundings being the ordinary temperature of the room, these would be entirely stopped by a mass of water or a mass of ice. Ice is a little more opaque to heat rays than water. From the heat rays that are produced from an Argand burner only 11 per cent penetrate a small thickness of water. The penetrating rays, however, manage to pass through further and thicker layers of water. The filtering process is very complete, but the rays which penetrate pass on through the water unabsorbed.

This property of selective absorption which is shown by many substances is shown particularly for water, and it has only recently been proved experimentally that a large absorption band exists in the case of water for the longer heat rays. An absorption band is a band in the spectrum where the rays have been removed. Now to make the explanation clear, consider some examples. It is an exceedingly important point that I wish to bring out, and one which is to determine whether the long heat rays can penetrate water. Now first of all consider the spectrum. If we can study the light rays in regard to their absorption in bodies then we can apply our knowledge to heat rays. We find that each vapor or gas has its characteristic spectrum. A good illustration is afforded in the absorption spectrum of iodine or bromine vapor. The light transmitted through the vapor when refracted through a prism shows dark bands together with characteristic colors. These dark bands show where the light at that particular wave has been filtered out and been absorbed in passing through the vapor.

Often the dark patches or absorption bands extend for a long distance through the spectrum.

Tyndall showed that the long rays from copper heated 100 degrees are all stopped by water. Rubens and Aschkinass have shown that there is a dark band (an absorption band) in the heat spectrum of water, and therefore there may exist heat rays beyond this absorption band for the longer waves which will penetrate the water. There is nothing to prevent our making that assumption. I will admit that it is yet to be proved that such exists, but that such could exist seems entirely plausible. Take the bed of a river which is at the freezing point radiating heat off into space. The waves of heat which will pass off will be very long and they very probably consist of waves beyond the absorption band discovered by Rubens and Aschkinass.

* Abstracted from a paper read by Dr. Howard T. Barnes before the American Society of Mechanical Engineers.

Determination of Fluorides and Other Antiseptics in Beers.—The antiseptics employed for the preservation of beers are usually soluble in water, and their determination is effected in the solution. Instead of the evaporation of the water and the examination of the residue, a rapid indication of the presence or absence of fluorides is secured by the Leys process, given in the Journal de Pharmacie et de Chimie, which depends on the classification of the water, always rendered turbid by the addition of a two per cent aqueous solution of picric acid; this precipitates the albuminoid matters and does not dissolve the phosphate of lime in suspension. The filtrate, limpid but colored yellow, treated with the solution of a calcium salt, is clouded on boiling, by the formation of calcium fluoride, in case of the presence of fluorides. The search for alkaline fluoborates and fluosilicates is effected in the same way. M. Leys advises the employment of citro-phosphate of lime as a reagent, which is obtained by the addition of the precipitated phosphate of lime to a boiling solution of citric acid. The reagent keeps well by the addition of a few drops of formal.

ELECTRICAL NOTES.

Owing to the frequency of accidents to London firemen in handling live electric light wires, the Fire Brigade authorities have decided that India-rubber gloves shall be carried with fire escapes and fire engines. Many firemen have been temporarily incapacitated by electric shocks they have received, owing to inadvertently grasping a "live" wire while working in the darkness and smoke of cellar fires. By using such protective gloves, it is hoped that even temporary inconvenience to the men may be averted.

A problem of real moment to both suppliers and users of electrical energy would be the discovery of a direct method of producing artificial cold by electrical means. If we had a ready means of producing artificial cold so as to obtain cold storage in our larders and so preserve our perishable foods, vegetables, and fruit, it would obviously greatly add to the pleasure of our lives and to the economy of our housekeeping. Of course, we can now produce artificial cold by connecting an air compressor to be driven by an electric motor, and by expanding the air into the cold-storage chamber, but the method is costly and cumbrous. Probably something may be done by a well-designed high-speed air compressor, but the real solution we are looking forward to is a direct method of producing cold from the electrical energy in our supply mains, and this probably is a problem for the electro-chemist, as we may conceive the apparatus taking the form of a battery abstracting heat from the surrounding air.

Quite recently we have witnessed the introduction of lamps yielding strange-colored lights, on the one hand the blue of the Cooper-Hewitt mercury vapor lamp, and at the other end of the scale the orange flame carbon arc lamp. An investigation into this question of the colors which are best suited to obtain clear visual definition by artificial light is sorely needed. Such an investigation was begun ten years ago by Langley in America, Blondel in France, and by Barr and Phillips in this country, but of late years little further has been heard on this extremely important subject. The revival or reintroduction of these modern lamps shows that the problem is an important one. More than twelve years ago Langley defined the brightness of light as the intensity of retinal absorption, and probably this is what most of us believe it to be. He pointed out that the effect of lights of different colors on the retina varied with the individuals and with the age of individuals, so that the greatest visual intensity is obtained with younger men when the light is rich in yellow rays, with the older men when the light is richer in the green and violet. Now that we have at command electric lamps that can give us colors of both kinds, it will be interesting to notice how far Langley's ideas are corroborated now that we have such full opportunities for investigating them on a larger scale. We are told that the Cooper-Hewitt lamp gives excellent definition and does not fatigue the eye when exposed to the trying work of reading fine scales, or wherever high definition is of first importance, and has to be obtained by the aid of artificial light.

Preparation of Oxy-hydrogen Gas by the Alternating Current.—Vanname and Graffenberg publish in the Zeitschrift für Elektrochemie an account of researches which they have made on the decomposition of water by the alternating current. The realization of practical apparatus for this purpose would present great interest in consequence of the facility of transformation of the current allowing of high intensities under low tensions.

The factors which influence the yield are the density of current and the frequency. The investigators have operated with a nearly constant frequency (50 to 55) and have employed as electrolytes, sometimes, acidulated water (20 per cent) and sometimes a solution of potash at the maximum of conductivity. They have made use of various electrodes (charcoal, silesium, and different metals) and in each case have measured the percentage of gas obtained, and the yield. They have also made qualitative observations on the manner in which different electrodes behave.

The highest yields observed are about half of those obtained with the continuous current. By reason of the attack of the electrodes these yields can be obtained only for a limited time.

No substance has been found perfectly suitable for the electrodes; there does not seem to be a matter which with the alternating current will resist the high densities. Charcoal is pulverized and affords but a slight yield; silesium is attacked only slightly in acid solution, but presents strong resistance of passage, as well as aluminium; platinum is attended with a slow dissolution and a superficial modification; the same is the case with platinum with 20 per cent of iridium; gold is pulverized with great densities of current. For the employment of the alkaline solution, silver is, perhaps, the most appropriate metal; still it dissolves slowly. With a density of current of seven amperes per square centimeter, the mixture produced contains an excess of hydrogen of about 2.50 per cent.

In order to meet the competition that has been created by the street electric trolley car in the potteries of North Staffordshire (England) the railroad company serving the district is substituting a system of steam-motor coaches in the place of the ordinary railroad service. These vehicles will fulfill the same functions as the trolley cars, only running upon the railroad track. Passengers will be picked up and set down wherever they desire. The cars will have seating accommodation for forty passengers, together with provision for carrying baggage. For facility in handling and to save time at the various termini, it will be possible to drive the coach from either end. By this service the railroad authorities anticipate retrieving a large amount of the traffic they have lost to the more frequent trolley service car.

ENGINEERING NOTES.

Boiler furnace efficiency has been defined as the ratio of the total heat delivered from the furnace to the total heat value of the coal consumed. This definition, however, does not take into account the temperature accompanying heat development, which is the most important factor involved, because full heat development is possible at a temperature so low as to make it impossible for any of it to flow into the boiler. Heat development can be of no use to the boiler unless it is at sufficiently high temperature for such heat to flow into it. Therefore, a definition of furnace efficiency is incomplete, if it neglects the matter of temperature. It is not only useful but necessary to recognize the distinction between heat and temperature. As in electricity, a small amount of current flows if the voltage is low, but if voltage is high, a large amount will flow in a very small wire; thus the temperature is the motive power which causes transfer of heat from the gases to the water in the boiler, which transfer is in direct proportion to the elevation of temperature.

Efficiency in steam generation is a very complicated problem. It is a function of some constants and many variables, therefore it is necessary to consider and take into account the individual features and their influences. Especially is this necessary for proper selection or for the development of superior apparatus, and proper consideration of these matters requires a more exact definition of some terms used, than prevail at present. For example, the word boiler is employed indiscriminately to designate either the boiler proper or the combination of it with other apparatus. Likewise the efficiency of a boiler, and the efficiency which may be produced through it, are commonly considered as being the same.

An action was recently brought before the Chancery Division of the High Court of Great Britain by William Edward Covrigall against Sir William G. Armstrong, Whitworth & Co. Ltd., the eminent naval ordnance manufacturers, for an injunction against the latter for infringing his patent for improvements in mounting ordnance and in the machinery of the apparatus. Mr. Covrigall maintained that during 1891, and down to the present time, the defendants had been manufacturing shields adapted to recoil when struck by a projectile, which he said were an infringement of his patent. Sir William Armstrong, Whitworth & Co. denied infringement, and pleaded anticipation. They contended that at the sale of plaintiff's patent the matters disclosed in various specifications of an earlier date with respect to gun-mountings and sighting arrangements, and to the use of shields for protecting guns, and to the manner of mounting shields and armor plates upon elastic backings or frames, were such as to make the plaintiff's letters patent invalid for want of subject matter. For the plaintiff it was contended that he had succeeded in making the attachment of the shield to the mounting of the gun an elastic attachment instead of a rigid one, so that the shield in itself had a certain possibility of recoil, independent altogether of the mounting of the gun. Interesting evidence concerning older specifications for gun shields was submitted by Messrs. Armstrong, and the court decided in their favor.

The production of copper forms one of the most important parts of the metallurgical industry of Japan. The copper is found generally in the form of pyrites. The ore production, which increases every year, exceeded 27,000 tons in 1900, and at present Japan occupies the fourth place in the world's market, after the United States, Spain, and Chile. The copper mines are numerous and extend over the whole country. In 1882, outside of the mines which gave silver, gold, and lead at the same time, there were thirty-five mines which were operated by private companies. The smallest mine yielded \$10,000, while the largest ones such as the Besshi mines, situated in the north of the country, gave as high as \$600,000. These latter mines are the second in importance in Japan, and have been worked for centuries past. The ore which is taken from them contains 9 per cent of pure copper. European methods and the most improved machines are now being applied here. As many as 8,000 men are employed in the mines and factories and the annual exportation to London figures for 4,500 tons. The highest production is reached in the Ashio mines near Nikko, in the north of the island of Hondo. The pyrite which is extracted has a value of 19 per cent copper and the annual production reaches 6,000 tons. These mines as well as the metallurgical works are operated by the Japanese. It is stated that the mines of Ashio and Besshi produce one-third of all the copper which is furnished by Japan. In 1900 the exports of refined copper from the country were figured at \$6,000,000, and in 1901 at \$7,000,000. Most of the copper which is produced is consumed in the country itself.

A circus train was pulling out of Spokane, Wash., a few weeks ago when suddenly the injector "broke" and persistently refused to take up water. After working with it a few minutes the engineer ordered an examination made of the tank; it was found nearly empty, although filled at the water crane but a short time before. No explanation of this mystifying condition was apparent until water in numerous streams was seen running from the elephant car next to the tender, and then the cause was found. "Jumbo" had amused himself by reaching his trunk through the open end of his car into the manhole of the tender and sucking up the water with which he had deluged the other animals in the car. They looked like "drowned rats," and needless to say had enjoyed their involuntary baths no more than the trainmen had the delay.—Railway Machinery.

TRADE NOTES AND RECIPES.

Estimation of Sulphuric Acid.—According to the Zeitschrift für Angewandte Chemie, F. Raschig adds to the acid or neutral solution to be analyzed 150 cubic centimeters of a solution of chlorhydrate of benzidine (18.5 grammes of benzidine per liter) for each decigramme of sulphuric acid, filters after five minutes of rest and washes with a little water. The filter is then put in an Erlenmeyer flask with 50 c.c. of water and shaken smartly for disaggregation, which gives a mixture of paper and benzidine sulphate; this is titrated with tenth normal soda at the temperature of 50 deg. C. after addition of a drop of phenolphthalein. Toward the close of the operation, in order to make sure of the total decomposition of the benzidine sulphate, the mixture is raised to the boiling point. This process is applicable to free acids, as well as to the sulphates. The presence of ferric salts interferes with its employment, and starch prevents the complete precipitation of the benzidine sulphate.

Filtration of Formaldehyde.—The Chemiker Zeitung gives a new method by Herr Lemme. When formaldehyde is made to act on a neutral solution of sodium sulphite, there is formation of caustic soda and the bisulphitic compound of formal; 100 cubic centimeters of a solution of 250 grammes of sodium sulphite in 750 grammes of water are neutralized with a few drops of a solution of sodium bisulphite, making use of phenolphthalein as indicator; then 5 cubic centimeters of the solution of formaldehyde to be examined are added, which produces a red coloration. The caustic soda formed is titrated with a normal solution of sulphuric acid. The difference between two titrations may amount to 1/10 or 2/10 of a cubic centimeter; but as 5 cubic centimeters of formal of 40 per cent require about 75 cubic centimeters of normal sulphuric acid, the error is inappreciable. Each cubic centimeter of the normal acid solution corresponds to 0.03 gramme of formaldehyde.

Preparation of Saké, the Japanese National Beverage.—Saké forms the national drink of the Japanese, and may pass as a sort of rice beer. It is a translucent liquid of agreeable odor, which in color resembles Rhine wine. Its very pleasant taste is mild, though somewhat bitter and tart; while its aroma is very peculiar and exceedingly delicate. Chemically considered, the brew has the following composition:

	I.	II.
Density	0.9955	0.9892
Alcohol	13.72	13.49
Extract	2.45	3.22
Sugar	0.42	0.94
Dextrin	0.24	0.51
Glycerin	0.95	1.08
Albumens	0.88	0.90
Ash	0.08	0.27
Acid	0.28	0.27

Saké is preserved in porcelain jars, in which it is heated to 45 deg. C. (113 deg. F.) before coming on the table; in the place of glasses, small conical cups of porcelain are used. If drunk warm, it is better than cold.

For the production of saké, according to the Böhmischer Bierbrauer, rice, water, and tané-koji are required. The last-named is a coarse-grained powder prepared from two varieties of fungi—the *Aspergillus orizae* and saké yeast. The former forms the saccharizing agent, while the latter causes alcoholic fermentation. By adding tané-koji to the warm rice pulp, and protecting it from cooling, the *Aspergillus orizae* spreads very quickly with favorable conditions of temperature, and soon covers the surface of the mass with its whitish mycelium, converting at the same time the starch into sugar. Simultaneously the yeast develops strongly, and causes a violent alcoholic fermentation.

To prepare koji, the rice is carefully washed, continuing this operation until the water which runs off remains absolutely clear, whereupon the rice is soaked in clean water. The steeping water is renewed twice a day. Steeping is continued until the grains are swollen and rather soft, which is generally attained in 24 to 36 hours. Next the rice is rinsed again, and heated with steam until the grains become perfectly pasty. The rice thus boiled is spread on mats in the cellar, and during the cooling is turned, to prevent the grains from sticking together. As soon as the temperature has dropped to 30 deg. C. (86 deg. F.) tané-koji is added in the proportion of 0.15 per cent by volume, and intimately mixed with the pulp. Now the rice is pounded and covered with several layers of matting, to avoid loss of heat by radiation. After 22 to 24 hours the aspergillus mycelium will appear. It is then mixed again, and stamped together once more to produce homogeneity of the mass and even temperature in the same. After the expiration of a few hours, the rice is distributed in boxes of one to ten quarts.

Piles of ten of these rectangular wooden boxes are set up along the cellar walls. From time to time each box is shaken, and its place exchanged with others of the same pile. With this manipulation a few hours suffice for the mycelium of the aspergillus to permeate the contents, and for a distinct development of the sweetish taste in the rice. This completes the preparation of the koji, which is preserved in cool places.

The temperature of koji varies from 27 to 38 deg. C. ($85\frac{1}{2}$ to $100\frac{1}{2}$ deg. F.) If this temperature is exceeded, a considerable development of fungi ensues, which

should be avoided. The mistake committed will be apparent from the yellowish-brown color of the mass, due to the aspergillus spores.

SELECTED FORMULÆ.

A Washing Compound.—This refers particularly to what is known as the "Grosser washing brick." It is made of 38.21 parts of sodium hydrate, 661 parts of sodium biborate, and 1.70 parts of sodium silicate added to 54 parts of water.—Nouvelles Scientifiques.

A Good Hair Oil.—Such a toilet requisite may be prepared very cheaply; the major part of it is in fact oil of sesame, of which we take about 1 kilogramme. To this add 12 grammes of lavender oil, 20 grammes of oil of lemon, 5 grammes of oil of rosemary, and 2 grammes of oil of geranium.

A Liquid Compost for Flowers in Pots.—Dissolve 2 parts of ammonium chloride with 4 parts of sodium phosphate and 3 parts of sodium nitrate in 80 parts of water, and filter it. This fertilizer can only be used in a very dilute state, not stronger than 25 drops in a liter of rain water.

To Protect Gilt Frames from Flies.—Since there is great risk of damaging the gilt when trying to remove the flyspecks with spirits of wine, it has been found serviceable to cover the gilding with a copel varnish. This hardens and will stand rough treatment, and may be renewed wherever removed.—Nouvelles Scientifiques.

Restoring Faded Photographs.—For the regeneration of faded photographs, the Pharmaceutische Zentralhalle recommends the following process: After carefully removing the picture from the cardboard, it should be bleached out with the following solution, in which operation pictures toned with gold do not disappear entirely: Hydrochloric acid 2 cubic centimeters, sodium chloride 8 grammes, potassium dichromate 8 grammes, and distilled water 250 cubic centimeters. Upon thorough washing the picture is again brought out by means of a highly diluted alkaline developer.

Fireproofing and waterproofing of textures, portières, tent cloth, stage decorations, etc., is accomplished by impregnating them with the following mass: Boil together, with constant stirring, the following ingredients until a homogeneous mass results:

	Kilos.
Linseed oil	77
Litharge	10
Sugar of lead	2
Lamp black	4
Oil turpentine	2
Umber	0.4
Japanese wax	0.3
Soap powder	1.2
Manila copal	0.7
Caoutchouc varnish	2.0

—Der Chemisch-Technisch Fabrikant.

To Remove Aniline Stains.—An excellent medium for the removal of aniline stains, which often are very stubborn, has been found to be liquid opodeldoc. After its use the stains are said to disappear at once and entirely.—Süddeutsche Apotheker Zeitung.

To Color Water for Druggists' Bottles.—Nottberg gives the following receipts for the coloring of the water in the large show bottles:

Green.—Copper sulphate 300 grammes, hydrochloric acid 450 grammes, distilled water to 4,500 grammes.

Blue.—Copper sulphate 480 grammes, sulphuric acid 60 grammes, distilled water to 4,500 grammes.

Yellowish Brown.—Potassium dichromate 120 grammes, nitric acid 150 grammes, distilled water to 4,500 grammes.

Yellow.—Potassium dichromate 30 grammes, sodium bicarbonate 22.5 grammes, distilled water to 4,500 grammes.

Red.—Liquid ferric chloride, officinal, 60 grammes, concentrated ammonium acetate solution 120 grammes, acetic acid, 30 per cent, 30 grammes, distilled water to 9,000 grammes.

Crimson.—Potassium iodide 7.5 grammes, iodine 7.5 grammes, hydrochloric acid 60 grammes, distilled water to 4,500 grammes.

All the solutions should be filtered. If distilled water be used, these solutions should keep for five to ten years. In order to prevent them from freezing, either add 10 per cent of alcohol or reduce the quantity of water by 10 per cent.—Pharmaceutische Zeitung, Berlin.

Roofs Covered with Tar Paper, Paint for Roofing Paper, etc.—

		Parts.
1.	Distilled coal tar	70
	Heavy mineral oil (lubricating oil)	10
	American rosin	20
2.	Distilled coal tar	50
	Trinidad asphalt	15
	Mineral oil, containing paraffine	10
	Dry clay, finely ground	25
3.	Distilled coal tar	50
	Colophony	15
	Rosin oil	5
	Dry clay-slate, finely powdered	30
4.	Distilled coal tar	70
	Colophony	20
	Linseed oil varnish	8
	Finely powdered pyrolusite	2
5.	Distilled coal tar	50
	Colophony	15
	Linseed oil varnish	7
	Pyrolusite	1
	Dry clay, finely powdered	27

—Neueste Erfindungen und Erfahrungen.

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